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THE LIME INDUSTRY OF THE PHILIPPINE ISLANDS

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TWO PLATES

The calcination of limestone and oyster and other marine shells for the production of lime has been practiced in the Philippines from time immemorial. The old adobe-stone wall surrounding the Walled City, which was built by the Spaniards over three centuries ago, was constructed with lime mortar. Adobe-stone buildings in the Walled City, some of them over a century old, were likewise laid in common lime mortar.

Two methods are used in burning the calcareous materials. One method consists of erecting a bundle of dried bamboo, about 30 centimeters in diameter and from 2 to 2.5 meters in height, in the center of an area of level ground. Wood fuel, 20 centimeters in diameter or less and about 1 meter long, is piled in circular form around the bamboo bundle as a center to a thickness of about 30 to 60 centimeters. A layer of calcareous material from 15 to 30 centimeters in thickness, depending upon the class of material to be burned, is uniformly spread over the pile of wood. Another layer of wood 30 centimeters thick is next put over the calcareous material, and so on, wood and calcareous material alternating until the end of the bamboo bundle is reached. The diameter of the pile is gradually decreased toward the top, so that the pile resembles a beehive. Provision is made for air channels radiating from the center to the circumference of the pile, to supply the necessary air for combustion. When everything is ready the fire is started by kindling the bundle of dried bamboo. When the bamboo is consumed the space it formerly occupied serves as a chimney.

The pile is allowed to burn until all the wood is consumed, which generally takes from two to three days. An attendant is always at hand to take care of the fire. When the burning is completed the pile is allowed to cool and, while still warm, the lime is slaked by pouring water into the several holes made through the mass of lime and afterward closing the openings. The surface of the pile is from time to time tamped with a shovel to prevent too rapid loss of steam. The amount of water added is just sufficient to pulverize the lime but not completely to hydrate it. The result is a dry white powder which, after sieving to remove pieces of charcoal and large lumps, is ready for use or for the market.

The other method, which is used only when burning limestone or coral rock, consists of first piling the larger pieces of stone to a beehive shape. The outer surface is filled with the smaller pieces of the rock. At one side of the base a hollow arc or dome reaching nearly to the center of the pile is provided which serves as a fireplace. The pile is then continuously fired, using wood as fuel. When the stones are considered to be sufficiently calcined, which usually takes from three to six days, depending upon the size of the pile, the firing is stopped and the lime later slaked in the usual way. It will be seen that in the first method the lime is mixed with the fuel ash, while in the second the lime is not contaminated to any great extent with the fuel ash. To be sure, a considerable portion of limestone is underburned; but, because the lime is slaked, any cores of unburned limestone are retained by the sieve. It will be readily appreciated that the fuel consumption in the two methods described must necessarily be excessive. On the other hand, the kilm can be put up at any convenient place and requires the minimum amount of capital. In small communities where lime is used only for local consumption it is still made by these primitive methods.

The excessive amount of fuel consumed in lime burning and the increasing cost of fuel led to the introduction of intermittent egg-shaped kilns in Guimaras Island and later in Baguio and elsewhere. Some kilns are 3.5 meters in largest diameter and 7.5 to 9 meters high. The kiln is generally located on the side of a hill to facilitate loading, and usually lined with common red brick, sandstone blocks, or adobe stone. In charging the kiln the largest pieces, seldom exceeding 30 centimeters in diameter, are arranged in the bottom of the kiln, forming an arc which serves as a fireplace. Instead of having an arc for a

fireplace some kilns are constructed with grates made of blocks of sandstone to support the column of limestone. The wood is burned under the sandstone grate. The kiln is charged with stone of gradually decreasing size until completely filled. The burning is conducted in the same manner as in the native method until the burners consider the stone sufficiently calcined. The kiln is then allowed to cool and the lime raked out and subsequently slaked. This method is undoubtedly more economical of fuel than the native method of burning in the open air and results in considerably fewer underburned stones. However, the intermittent nature of the operation requires that the kiln be cooled to allow recharging. The reheating and cooling of the kiln cause considerable loss of heat and consequently entail greater fuel consumption than the continuous kiln. In Baguio about 3 cubic meters of pine wood are required to produce 1 ton of lime.

Another method of lime burning, introduced by the Chinese and used at the present time, consists of a circular kiln (Plate 1) 3 to 4 meters in diameter and about 1.5 meters high. It is made entirely of adobe-stone blocks. From a point on the side of the bottom of the kiln radiate several air channels which serve to supply the air necessary for combustion. A circular wooden fan, operated either by man power or by an electric motor, forces the air into the air channels in the bottom of the kiln. Various fuels are used; such as, spent tanbark, rice husks, and coke breeze. The calcareous material used is generally oyster or other marine shells, although hard limestone in small pieces has occasionally been used. To charge the kiln, the air channels are filled first with wood shavings loosely covered with blocks of adobe stone in order to allow the passage of air. If coke dust is used as fuel, a layer 5 to 8 centimeters thick of rice husks is first spread over the bottom of the kiln, followed by a layer of coke dust. It is said that the object of using rice husks is to start the fire uniformly over the entire bottom of the kiln. A layer of marine or oyster shells is spread uniformly over the coke dust and so on, fuel and shells alternating in the ratio of one volume of coke dust to every four to five volumes of shells, until the kiln is full. Some operators mix the fuel and the shells in small batches and charge the mixture into the kiln over the first layer of coke dust until the kiln is completely filled.

To start the kiln the wood shavings near the fan are set afire and then the fan is started. The blast of air gradually drives

the flame farther and farther into the air channels, thereby kindling the rice husks immediately above. Three men are required to operate the kiln. Two operate the fan, and one extra man replaces those turning the fan with their feet whenever one of them feels tired. He also looks after the burning operations, particularly to prevent the formation of fire holes, by filling the openings with shell or with a mixture of shell and fuel. After ten to fourteen hours of continuous burning, the process is completed and the kiln is allowed to cool overnight. The calcined shell is generally sieved through a half-inch mesh. The portion passing through the sieve contains most of the impurities, consisting of burnt mud or fine particles of earth, originally adhering to the shells and ash from the fuel used. This impure product is slaked and finds a good market for making common lime mortar. The portion retained on the sieve is separately slaked. It is relatively pure and therefore commands a higher price in the market. It is used to some extent in sugar manufacture, for making lime-oil (lumbang) paste, used extensively in wooden-boat construction, and as a depilating agent in leather manufacture. The following data were collected in an investigation of one of these kilns located on the banks of Estero de Vitas in Tondo, Manila, during October, 1927.

CALCAREOUS MATERIAL

The raw material used is a variety of sea shells obtained from the fishery beds in Bulacan and Pampanga Provinces. A smaller quantity is obtained from the shallow water of Manila Bay along the shores of those two provinces. The shells are loaded into river boats and sent direct to the kilns. The shells as delivered are wet and contain considerable quantities of adhering mud. No effort is made at the kiln to clean them before calcination on account of the expense involved. The shell costs from 50 to 55 centavos per cavan of 75 liters delivered at the kiln site and weighs 77.25 kilograms. One cubic meter, therefore, weighs 1,030 kilograms and costs from 6.66 to 7.33 pesos,[1] or from 6.47 to 7.12 pesos per ton.

FUEL

The fuel generally used is coke dust, obtained from the Manila Gas Corporation as a by-product in the manufacture of coal gas. The coke costs 11.50 pesos per ton, delivered at the kiln

[1] One peso Philippine currency equals 50 cents United States currency.

site. A few bags of wood shavings and rice husks are also used in order to start the calcination process properly. The coke pile is in the open air and frequently becomes wet on account of the rain. When dry the heat value is from 5,500 to 6,000 calories and from 16 to 17 per cent ash. The cost of manufacturing lime from marine shells, using coke dust as fuel, is as shown in Table 1.

TABLE 1.—*Cost of manufacturing lime from shells, Chinese process.*

Materials:		Pesos.
110 cavanes (8.5 tons) of shells, at 0.55 peso per cavan		60.50
1.23 tons of coke dust, at 11.50 pesos per ton		14.00
Rice husks and wood shavings		1.50
Total cost of materials		76.00
Labor:	Pesos.	
Three men for loading the kiln one day, at 2 pesos	6.00	
Three men for burning the charge one day, at 2 pesos	6.00	
Three men for unloading the charge and slaking the lime one day, at 2 pesos	6.00	
Total cost of labor		18.00
Total cost of slaked lime		94.00
Total slaked lime produced, cavanes		170.00
Cost of slaked lime per cavan (75 liters), peso		0.55
Lime per kilogram of fuel, kilograms		4.20
Weight of unslaked lime per cavan, kilograms		45.25
Weight of slaked lime per cavan, kilograms		42.00

It will be observed that the cost of 0.55 peso per cavan of slaked lime does not include interest and depreciation on the investment. The capital required to operate a kiln of this capacity in the City of Manila is approximately as follows:

	Pesos.
Land	2,000
Building	1,500
Adobe-stone kiln and fan	1,000
Working capital	1,000
Total investment	5,500

Assuming ninety burnings per year, of 170 cavanes of slaked lime each, there would be a total production of 15,300 cavanes. Interest on 5,500 pesos at 10 per cent per year would amount to 0.036 peso per cavan. Repairs and depreciation, 2,500 pesos

at 10 per cent per year would be 0.016 peso per cavan, making a total fixed charge of 0.05 peso per cavan. The total cost of manufacturing slaked lime from marine shells is therefore about 0.60 peso per cavan.

In Malabon and Navotas, Rizal Province, and in Meycauayan, Bulacan Province, spent tanbark is used in burning lime. It is considered as a waste product from the tanneries and is given away free to lime burners. In spite of the fact that spent tanbark can be delivered to the kiln for about 1 peso per cubic meter, the total costs of production is not very much less than when coke dust is used. This is due to the fact that spent tanbark occupies a large space and the kiln production is about one-third less than when coke dust is used.

As would be expected, the purity of the quicklime is very low, due to the adhering mud in the raw material and to the ash of coke dust used and also to incomplete calcination. The average quicklime content is about 70 per cent (see Table 2). The fuel-lime ratio on the basis of 95 per cent lime would be 3.1 kilograms of lime per kilogram of fuel, instead of 4.2 as given in Table 1.

Table 2 shows the analyses of the raw material and of the lime and the slaked lime produced.

TABLE 2.—*Analyses of marine shells and resulting lime.*

Constituent.	Shells as usually delivered.		Shells considered dirty.			
	Unburned shell.	Common slaked lime produced.	Unburned shell.	Unslaked lime produced.	Extra-quality slaked lime produced.	Common slaked lime produced.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Loss on ignition	41.20	27.48	40.58	9.44	29.52	25.02
Silica (SiO_2)	6.40	11.21	7.74	7.50	4.48	16.93
Aluminum and iron oxides (R_2O_3)	1.20	2.68	1.74	2.88	1.08	3.34
Calcium oxide (CaO)	50.44	56.51	48.86	79.34	63.38	52.76
Magnesia (MgO)	0.38	0.60	0.46	0.65	0.50	0.49
Carbon dioxide (Co_2)	--------	7.11	--------	7.84	4.64	7.10
Approximate composition:						
Moisture	1.3	4.8	1.6	--------	6.2	3.8
Sand and siliceous material	6.4	11.2	7.7	7.5	4.5	16.9
Iron oxide and alumina (Fe_2O_3-Al_2O_3)	1.2	2.7	1.7	2.9	1.1	3.3
Calcium carbonate ($CaCO_3$)	89.9	16.1	87.4	17.8	10.5	16.2
Magnesium carbonate ($MgCO_3$)	0.8	--------	0.9	--------	--------	--------
Calcium oxide	--------	--------	--------	64.6	--------	--------
Calcium hydroxide	--------	62.7	--------	6.5	76.0	57.6

It will be seen from the table that the unslaked lime contains only about 70 per cent of actual lime and 30 per cent of impurities. The slaked lime of "extra quality," which was obtained by slaking that portion of the quicklime retained on a half-inch mesh, contained 76 per cent of hydrated lime; while the portion that passed through the sieve, which contained most of the impurities, the resulting hydrated lime was only 57 per cent. However, if limestone of good quality were used and the resulting lime were passed through a sieve so as to remove most of the fuel ash, the lime remaining on the sieve would undoubtedly be suitable for chemical purposes.

CONTINUOUS LIME KILNS

In 1913, the establishment of modern sugar centrals may be said to have started in the Philippines. They required a high grade of lime which could not be satisfactorily furnished by the lime kilns then in operation. Lime was, therefore, imported from America, Japan, and China. In 1914, I constructed a small, vertical, continuous kiln from a design made in the Bureau of Science to supply the necessary lime required by the two sugar centrals, one at Calatagan and the other in Look, Batangas Province.

The raw material used was coral rock obtained from the shore of Balayan Bay, and the fuel was mountain wood. The kiln had an internal diameter of 75 centimeters and a total height of 5 meters, and had two fireplaces. The capacity of the kiln was from 0.75 to 1 ton of lime per day. The kiln has given entire satisfaction, and I understand that it is still being used.

During the World War a considerable number of sugar centrals were erected in the Philippines, particularly in Negros. Large quantities of lime were imported from abroad to supply the high-quality lime demanded by the sugar centrals.

To study the commercial feasibility of manufacturing a high-quality lime from Philippine materials, the Bureau of Science made practical burning tests of limestone obtained from several available deposits. In 1915 Thurlow,[2] using a vertical continuous kiln with a sirocco suction fan, demonstrated that lime of superior quality could be obtained from this type of kiln.

In 1917, a new kiln was constructed in the Bureau of Science, embodying certain improvements which previous experience had shown to be desirable. A sketch of the kiln is given in Plate 2.

[2] Philip. Journn. Sci. § A 11 (1916) 129.

In this kiln only the flame comes in contact with the limestone, so that the lime does not become contaminated with ash from the fuel.

The analyses of limestone and fuel used in the burning tests made in 1918 by the division of general, inorganic, and physical chemistry, of the Bureau of Science, are given in Table 3.

TABLE 3.—*Chemical analyses of limestones used in tests.*

Constituent.	Palsanbañgan, Tayabas.	Montalban, Rizal.	Binañgonan, Rizal.	Cebu.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Loss by ignition	43.48	43.98	43.70	42.36
Silica (SiO_2)	0.69	0.26	0.61	2.62
Alumina iron oxide (R_2O_3)	0.35	0.09	0.52	1.08
Calcium oxide (CaO)	54.68	54.97	53.98	53.28
Magnesia (MgO)	0.48	0.62	1.12	0.50

The computed composition of the quicklimes obtainable from the above limestones, assuming complete calcination, are given in Table 4.

TABLE 4.—*Computed composition of quicklimes.*

Constituent.	Palsanbañgan, Tayabas.	Montalban, Rizal.	Binañgonan, Rizal.	Cebu.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
Silica (SiO_2)	1.2	0.4	1.0	4.5
Alumina iron oxide (R_2O_3)	0.6	0.2	0.9	1.8
Calcium oxide (CaO)	97.2	98.0	95.7	92.5
Magnesia (MgO)	0.8	1.1	1.9	0.8

Geerlings[3] gives the maximum impurities allowable in lime for use in sugar manufacture as follows:

	Per cent.
Silica (SiO_2)	2
Iron and aluminum oxides (Fe_2O_3 and Al_2O_3)	2
Magnesia (MgO)	2
Carbon dioxide (CO_2)	2
Sulphuric anhydride (SO_3)	0.5

It will be seen from the analyses of the limestones used that, with the exception of one from Cebu, all are sufficiently pure

[3] Geerlings, H. C. Prinsen, Cane Sugar and Its Manufacture, 2d ed.

so that, if properly calcined, the resulting lime would be well within the above requirements.

The Palsanbañgan deposit in Tayabas Province is a continuation of the limestone deposit at Binañgonan and Montalban in Rizal Province. They are hard crystalline limestones, sufficiently pure to produce lime of high purity. The southern line of the Manila railroad to Hondagua passes near the Palsanbañgan deposit. The lime produced in that district is shipped by rail to Manila.

The Binañgonan deposit is located about 5 kilometers from the town of Binañgonan. Limestone is carried by carabao carts to the town to be calcined. The Rizal Cement Factory, located near the shore of Laguna de Bay near the town of Binañgonan, obtained the limestone from the same deposit by means of an aërial cable about 5 kilometers long.

The Montalban limestone deposit is about 29 kilometers from Manila and can be reached by automobile over a first-class road. It is located on both banks of the Marikina River at Montalban, just below the dam of the Metropolitan Water District. The limestone is of a lighter color than that found in Binañgonan or Palsanbañgan and, unlike them, has the property of cracking when subject to the action of heat. This property allows the heat to penetrate the stone more quickly, and for this reason it is easier to calcine.

The Cebu limestone is coralline in nature, and analysis shows that it has less purity than have those already described.

Various fuels have been used in the tests to determine their relative efficiency. The analyses and the costs of the various fuels used are given in Tables 5 and 6. The results of the burning tests are given in Table 7.

TABLE 5.—*Analyses of various fuels.*

	Coconut shell.	Coconut husk.		Fushun coal.	Mangrove wood (rajas).
		Green.	Air dried.		
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Moisture (105° C.)	9.20	64.82	6.92	7.51	34.87
Combustible matter	73.45	25.25	66.80	41.91	
Fixed carbon	15.72	18.68	22.97	42.99	
Ash	1.63	1.25	3.31	7.58	1.14
Sulphur (separately determined)		0.07	0.19	0.64	
Total calorific value	4,418	1,674	4,430	6,657	3,254

TABLE 6.—*Cost of fuel in Manila.*

Kind of fuel.	Per ton delivered.	Per 1,000 pieces.	Per cubic meter.
	Pesos.	*Pesos.*	*Pesos.*
Fushun coal	20.00		
Coke dust	11.50		
Coconut shell and husk	12.00		
Mangrove wood (green); diameter, 7 to 15 centimeters	15.20	85.00	8.20
Mountain wood, large size; diameter, 10 to 20 centimeters			7.00
Mountain wood, mixed sizes			4.00

TABLE 7.—*Results of burning tests made in the Bureau of Science.*

Number of days run.	Fuel used.		Limestone.		Lime produced.	Underburned lime drawn.
	Kind.	Quantity.	Source.	Quantity.		
		Kg.		*Kg.*	*Kg.*	*Kg.*
11⅓	Fushun coal	7,047	Palsanbañgan, Tayabas	28,770	16,086	1,510
2	Mangrove wood	2,881	do	7,009	3,764	352
1	Coconut shell	1,477	do	3,400	1,732	
4⅓	Fushun coal	2,574	Montalban, Rizal	13,311	7,164	1,044
2	do	897	Binangonan, Rizal		2,136	
1	do	640	Cebu	3,370	1,670	245

Number of days run.	Fuel used.		Lime per 100 of limestone.	Lime per kilogram of fuel.	Lime produced per day of twenty-four hours.	Refuse from fuel.	
	Kind.	Quantity.				Weight.	Refuse per 100 of fuel.
		Kg.	*Kg.*	*Kg.*	*Kg.*		
11⅓	Fushun coal	7,047	55.8	2.27	1,415	1,628	23.1
2	Mangrove wood	2,881	53.7	1.31	1,882	113	3.6
1	Coconut shell	1,477	51.0	1.17	1,732	98	6.6
4⅓	Fushun coal	2,574	53.8	2.78	1,650	385	15.0
2	do	897		2.38	1,068	182	18.4
1	do	640	49.5	2.60	1,670	112	17.5

The pieces of limestone used in the burning tests varied from 8 to 15 centimeters in diameter. Natural draft was used. It was found that with this size of charge there was no necessity of having any chimney over the kiln, as the draft was sufficient after the kiln was thoroughly heated.

It will be noted from Table 7 that the refuse obtained from Fushun coal when Palsanbañgan stone was burned amounted to 23.1 per cent of the coal used, showing that a considerable amount of fuel was lost in the form of unburned carbon in the coal ash. This was due to the inexperience of the men

handling the fire and explains the low ratio of lime to fuel obtained. The best ratio was obtained with Montalban limestone in which 2.78 kilograms of lime were obtained per kilogram of Fushun coal. It has already been pointed out elsewhere that Montalban limestone cracks under the action of heat, although the stone is not actually split apart. The good lime-fuel ratio obtained in all probability is due to that property.

It is apparent from Table 7 that the kiln capacity is considerably increased when wood or coconut husk is the fuel used. Both fuels produce a long flame which raises the temperature of the stone to its decomposition temperature farther up the kiln than when the fuel gives a shorter flame. It was also observed that partially dried wood gave better results than did well-dried wood, perhaps due to the large quantity of water vapor produced by the combustion of partially dried wood by reducing the gaseous pressure in the kiln.

Three men per shift are required to operate the kiln, provided the fuel and the limestone are within reasonable distance from the kiln. Their work includes charging and firing the kiln and drawing and packing the lime produced. If we assume that the limestone of the required size delivered in Manila costs 10 pesos per cubic meter (about 1,300 kilograms) and that the capacity of the kiln is 1,500 kilograms per day when coal is used as fuel and 1,800 kilograms when wood is used, the relative costs of manufacturing a ton of lime in a vertical continuous kiln would be approximately as shown in Table 8.

TABLE 8.—*Cost of manufacturing one ton of lime, using various fuels.*

Fuel used.	Fushun coal.	Mangrove wood.	Coconut shells.
	Pesos.	*Pesos.*	*Pesos.*
1.4 cubic meters of stone at 10 pesos per cubic meter	14.00	14.00	14.00
0.4 ton of coal at 20 pesos (lime-fuel ratio 2.5 : 1)	8.00		
1.41 cubic meters of mangrove wood (762 kilograms) at 15.20 pesos per ton		11.58	
0.854 ton of coconut shell at 12 pesos per ton			10.25
Six men per 24 hours (two shifts per day of 3 men each) at 1.50 pesos each, per ton	6.00	5.00	5.00
Total cost of material and labor per ton of lime in bulk	28.00	30.58	29.25
Volume of 1 ton of lime ... cubic meters	1.02	1.02	1.02
Do ... cavanes	13.6	13.6	13.6
Slaked lime produced per ton of lime ... do	37.8	37.8	37.8
Weight per cavan (75 liters) of slaked lime ... kilograms	34.9	34.9	34.9
Cost per cavan of slaked lime ... peso	0.74	0.81	0.77

It will be seen from Table 8 that in Manila coal is a cheaper fuel than wood for use in lime burning. However, in places where wood is plentiful and near to the limestone deposit, wood will be cheaper to use than coal. Local conditions should, therefore, govern the choice of fuel to be used.

Three methods are now commercially used in lime burning; namely, egg-shaped intermittent kilns; intermittent low circular kilns (Chinese kiln) in which the fuel, usually coke, and calcareous material are alternately charged; and vertical continuous kilns with separate fireplaces. The Chinese process has been found to be more economical in fuel when the calcareous material used is marine or oyster shell, in which the thickness of the material is rarely over half a centimeter. If hard limestones are used they will have to be crushed to 1-centimeter size or less. The labor or power required in crushing the stones to such a small size is considerable, and this is believed to be the greatest disadvantage of the Chinese kiln. On the other hand, if larger pieces of limestone are charged, a large percentage of the resulting lime is underburned. The continuous vertical kiln, like that used in conducting the burning tests at the Bureau of Science, requires stone of a definite size to be calcined, if a satisfactory draft is to be maintained. A continuous kiln is more economical in fuel than is the egg-shaped kiln, but the latter is capable of utilizing stones as large as 30 to 35 centimeters in diameter, which is a decided advantage. The labor required in breaking up the stones for use in the egg-shaped kilns is, therefore, less than that used for the continuous kiln.

Where the calcareous material is naturally found in small pieces, such as marine or oyster shells, the Chinese kiln can be advantageously used. The continuous kiln is better adapted to supply a more or less continuous demand. However, if the demand is irregular, an egg-shaped kiln will probably be more suitable.

As a result of the burning tests conducted by the Bureau of Science, a lime kiln similar to that used in the Bureau of Science was erected at Malicboy, Tayabas, by a private company. The kiln has an inside diameter of 6 feet, is 28 feet high, and has two fire boxes 4 by 5 feet. The capacity of the kiln is from 4 to 5 tons of lime per day. Another kiln of similar design

was erected on Guimaras Island, Iloilo Province. Two other kilns were erected about 7 kilometers beyond Antipolo, Rizal Province, Luzon. The deposit itself is about 3 to 4 kilometers from the provincial road and can be reached by automobile during the dry season only. The limestone occurs in scattered bowlders more or less buried in the ground and is of the same quality as is that found in Binañgonan. It seems that the business was not a financial success as the two kilns have ceased operations.

As a rule, the sugar centrals demand unslaked lime, and the lime burners are therefore compelled to use air-tight containers to supply the demand. The cost of the container is a large item in the total cost. If second-hand wine or oil barrels of 55 gallons each are used, one ton of lime will require about six and one-half barrels which, at 1.50 pesos each, would total 9.75 pesos, excluding transportation of the empty containers to the kiln. Where second-hand 5-gallon tin cans are available, they can be used as lime containers, but they would cost more than oil barrels per ton of lime.

Slaked lime is easier and therefore cheaper to ship to the consumer than unslaked lime. Ordinary jute, palmleaf, or paper bags can be safely used. Slaked lime may be stored in bulk by the consumer and a rebate allowed on the return of containers in good condition.

The only possible objection to the delivery of slaked lime is the fact that freight has to be paid for the water added in slaking when the water can just as well be added at the central. However, containers for quicklime must be air tight and therefore are expensive, whereas the container for slaked lime need not be air tight. The difference in the cost of containers more than counterbalances the extra freight paid due to the water added in slaking. To be sure, the slaked lime should be of the same purity as the unslaked lime. The following specifications for lime and slaked lime for use in the sugar industry are given in the specifications of the American Society of Testing Materials.

SPECIFICATIONS FOR QUICKLIME AND SLAKED LIME FOR USE IN THE SUGAR INDUSTRY

1. Quicklime or slaked lime should be clean and free from gritty substances.

2. The quicklime or slaked lime should conform to the following requirements as to chemical composition, calculated to the nonvolatile basis:

	Per cent.
Calcium oxide (CaO), minimum	94
Magnesium oxide (MgO), maximum	2
Iron and aluminum oxide (F_2O_3 and Al_2O_3) and insoluble matter, maximum	2
Carbon dioxide (CO_2), maximum:	
(*a*) If sample is taken at place of manufacture—	
(1) Quicklime	3
(2) Slaked lime	5
(*b*) If sample is taken at other than place of manufacture—	
(1) Quicklime	5
(2) Slaked lime	7

SUMMARY AND CONCLUSIONS

1. The native methods of burning lime in the open air are described. They are wasteful of fuel and considerable underburned lime is produced. They are still used in small communities to produce slaked lime for local consumption.

2. The introduction of egg-shaped, intermittent kilns was a great improvement over the native method. The kiln is more economical in fuel than the native method, and perhaps the greatest advantage of this kind of kiln is the fact that it can utilize pieces of limestone as large as 30 to 35 centimeters in diameter.

3. For the calcination of calcareous material in small pieces the Chinese kiln, on account of its simplicity and fuel efficiency, is to be recommended. Oyster shells and other marine shells cannot be satisfactorily burned by any method now used except in the Chinese kiln, shown in Plate 1.

4. A vertical, continuous kiln, operating with natural draft has been introduced by the Bureau of Science with success. The largest size of this type of kiln in operation is 6 feet (about 1.83 meters) in its largest diameter and contains two opposite firing doors. The capacity per day is between 4 and 5 tons of lime. This size seems to be the limit for two firing doors and, if kilns of larger capacity are desired, three equidistant firing doors should be provided.

5. The cost of manufacturing common slaked lime in the City of Manila from marine shells in the Chinese kiln is 0.55 peso per cavan of 75 liters (42 kilograms). In calcination tests made at the Bureau of Science, using crystalline limestone with various fuels, the cost of manufacturing quicklime varied from 28 to 31 pesos per ton. This is equivalent to from 0.74 to 0.81 peso per cavan of slaked lime, of 75 liters. The cost given above is for materials and labor only, and does not include taxes, interest, depreciation, etc.

ILLUSTRATIONS

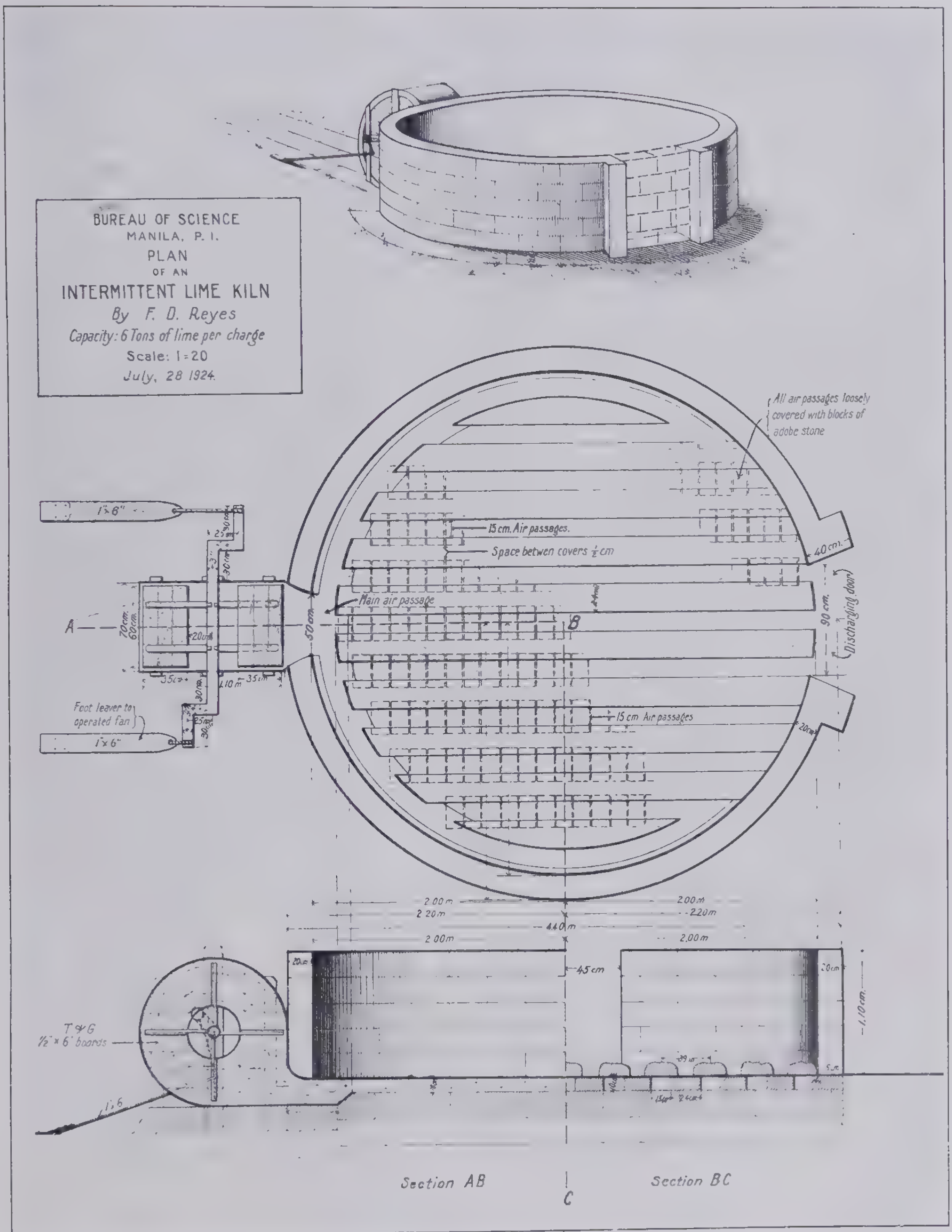

PLATE 1. AN INTERMITTENT LIME KILN.

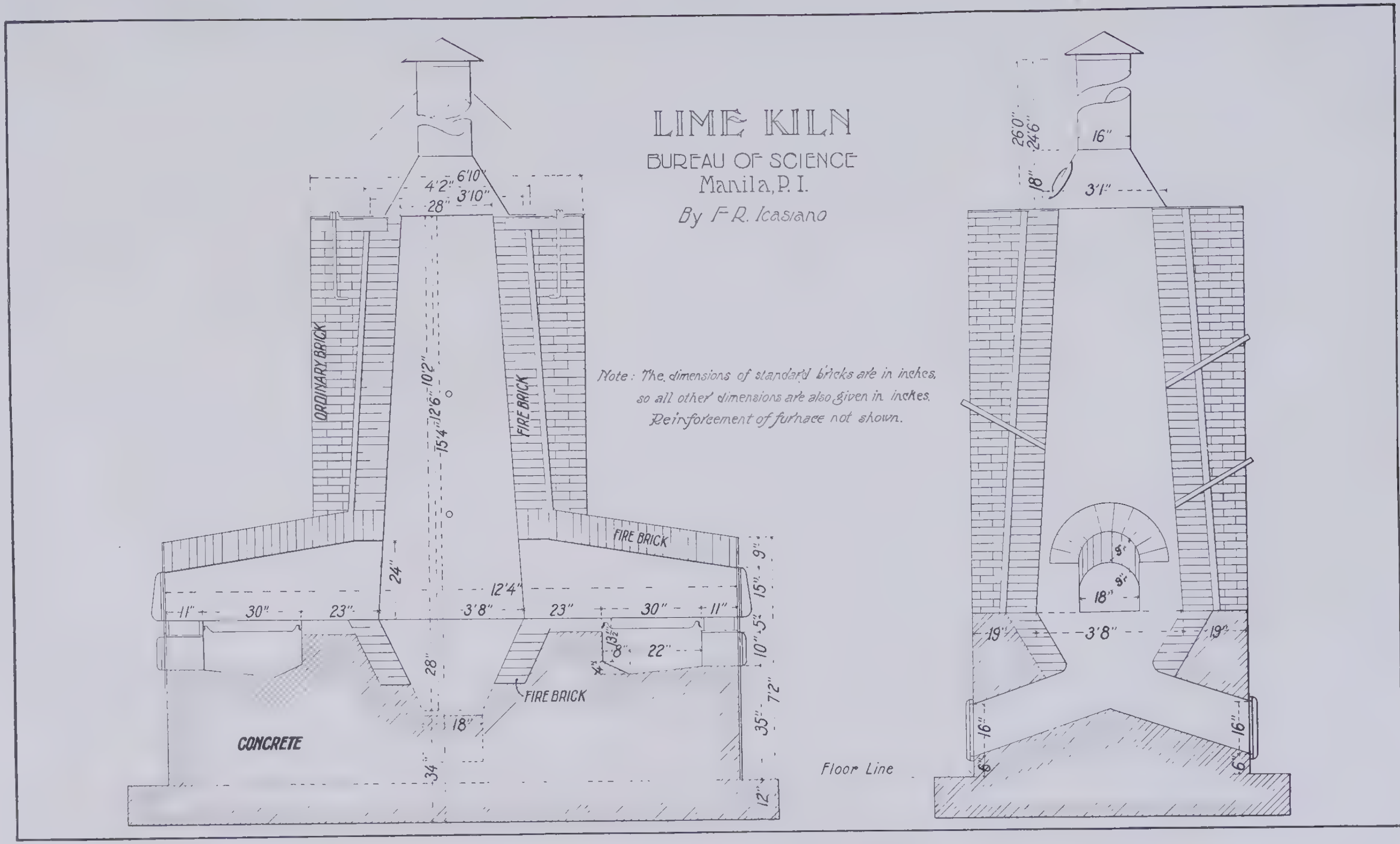

PLATE 2. AN IMPROVED CONTINUOUS LIME KILN.

COMPOSITION OF PHILIPPINE PINEAPPLES

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TWO PLATES

Early in April, 1927, it was realized that pineapple material brought to the laboratories of the Bureau of Science for specific analyses in connection with investigations in plant pathology might readily be utilized for making complete analyses of introduced varieties of pineapples and comparing the results with data obtained on native varieties as well as the same varieties grown in other countries. The purposes of this paper are to outline briefly the growth of pineapple culture in the Philippines; to give complete analyses of pineapples and their products grown under Philippine conditions; and to furnish comparative data and other information relative to the subject of the composition of pineapples, which will be of value for the marketing and canning of this fruit.

Pineapples were grown in the Philippines at a very early date. As early as 1595, Spanish priests were teaching the people the weaving of piña cloth and other fabrics from the fine fibers taken from the pineapple plant. It is understood that pineapples were introduced into the Philippines from Mexico by the Spaniards. In 1571, Miguel Lopez de Legaspi found the natives were using a fiber that was afterward identified by Dominican missionaries as coming from leaves of the small native pineapple, which was growing wild in many of the provinces of the Philippines. It appears that even up to the time of the American occupation pineapples were grown very little for their fruit. In 1912, Bataan was the only province producing any great quantity of fruit for the market.

The Bureau of Agriculture reports for 1902 and 1903 that there were only a few hundred hectares of land devoted to pineapple culture. At that time, the Manila market was supplied with native fruits brought from the barrio of Dumulong, Orion, Bataan. The Bureau of Agriculture[1] informs us that Samar,

[1] Bureau of Agriculture Circular No. 16.

Occidental Negros, Tayabas, Bulacan, Leyte, Cebu, and Zambales grew the plant more for its fiber than for its fruit. That bureau also states that a comparison of the soil and the climate of the Philippines with those of pineapple-growing countries in other parts of the world, and a consideration of the behavior of the pineapple in the Philippines, give assurance that with proper care the pineapple will succeed equally well in many parts of the Archipelago.

In 1911 and 1912, the Smooth Cayenne variety of pineapple was introduced into the Philippines. In 1911, the Abucay Plantation Company set out 10,000 Smooth Cayenne plants obtained from Hawaii, and so succesful was the result of this trial planting that later 40,000 more plants were imported from Hawaii, in two lots. The fruit grown at Abucay is in great demand on the Manila market as a substitute for the small inferior native variety. In the past, attempts have been made to introduce other varieties and to grow plants brought from Singapore, but for certain reasons Smooth Cayenne has advanced more rapidly than any of the others and is one of the best grades of pineapples found on the Manila market.

At present the two classes of pineapples found in quantity on the market are the native varieties and the Smooth Cayenne. We have been informed that the Black Prince variety has been introduced and is successfully grown for the trade; one company shows a production of approximately 85 per cent Smooth Cayenne and 15 per cent Black Prince.

The native pineapples (Plates 1 and 2) are smaller than the Smooth Cayenne. Unlike the Smooth Cayenne many of the native fruits taper toward the base. Except for size, some of the native varieties resemble Smooth Cayenne in being cylindrical or barrel-shaped. In general appearance native pineapples may be described as follows: Somewhat elliptical in shape; height, 8 to 17 centimeters; diamter, from 6 to 12 centimeters; color, orange, orange red, green, greenish yellow.

From one hundred nine assorted native Philippine pineapples the weights shown in Table 1 were obtained.

The eyes are set from 1 to 1.8 centimeters deep and display plenty of large seeds. The eyes vary in width from 1.5 to 3 centimeters. In general, per unit surface the native pineapple has more and deeper eyes than has Smooth Cayenne. The edible portion of the ripe fruit varies from opaque whiteness to translucent orange. The core of the native variety is proportionally thicker and harder than that of the Smooth Cayenne.

TABLE 1.—*Showing weights of native Philippine pineapples.*

Fruits.	Class.	Weight.	Weight of edible portion.
		g.	g.
1	Smallest fruit	640	340
109	Average fruit	995	630.6
1	Largest fruit	1,330	615.3

Plate 1 gives a general idea of the appearance of some common types of native pineapples found on the market. There is a great difference in the number of eyes found in the native species as well as in the flavor of the various fruits. In purchasing native pineapples some people prefer those of an orange or orange red color, while others select those that have a green surface when ripe. Plate 2, fig. 2, shows the difference in size of a large native pineapple and a large Smooth Cayenne.

The Smooth Cayenne grown in the Philippines is not unlike that found in Hawaii, in general appearance and in texture of the edible portion. This fruit often grows to a very large size. Pangasinan Province produced a fruit weighing 13 pounds (5.89 kilograms), while the largest pineapple grown by the Abucay Plantation Company weighed 16 pounds (7.25 kilograms). Plate 2, fig. 1, shows a field of Smooth Cayenne variety growing in Laguna Province at a possible altitude of 6 meters above sea level. Smooth Cayenne pineapples grown in the Philippines are in no way inferior to those grown in other parts of the world. Table 2 shows the weights of the smallest and the largest fruits, as well as the average weight of one hundred sixty-seven fruits analyzed in this work.

Smooth Cayenne pineapples are successfully grown in the Philippines at elevations of 200 to 250 meters above sea level. Approximately 20,000 selected suckers are planted per hectare. A hectare produces approximately 14,000 pineapples or, in other words, approximately 70 per cent of the plants planted bring in fruit either during the winter season of October to November, or the summer season of April, May, June, and July. This yield could undoubtedly be increased by the proper use of the correct artificial fertilizers. Table 3 shows the percentages of fruits of standard grades obtained per hectare (native pineapples are not graded).

The cost of planting a hectare, harvesting, and placing the pines on the market, not including cost of clearing the land, is

TABLE 2.—*Showing weights of Smooth Cayenne pineapples.*

Fruits.	Class.	Weight.	Weight of edible portion.
		g.	*g.*
1	Smallest fruit	1,150	1,067
167	Average fruit	2,567	1,808
1	Largest fruit	4,027	3,039

TABLE 3.—*Showing grades and values of Philippine-grown Smooth Cayenne pineapples.*

Grade.	Weight.	Per cent.	Pines per crate.	Wholesale price per crate.
	kg.			*Pesos.*
X	3 or over	0.8	8	9.00
No. 1	2.20 to 3	8.9	10	9.00
No. 2	1.50 to 2.20	31.3	14	8.00
No. 3	1.00 to 1.50	39.0	18	4.50
No. 4	0.75 to 1.00	18.3	35	3.50
No. 5	Under 0.75	1.7	50	3.50

approximately 700 pesos,[2] from the time of first plowing to the gathering and shipping of the fruit. For the clearing of ordinary foothill land, 180 pesos must be added per hectare. It is estimated that the cost of cultivation and weeding for the second and third crops after the first plant crop—that is, the two ratton crops—is approximately 300 pesos per hectare. The gross income per hectare from the first crop is approximately 1,200 pesos; the cost of production (not including clearing of the land) amounts to 700 pesos. The gross profit from the first crop is, therefore, approximately 500 pesos; the gross proceeds from the second and third crops amount to approximately 1,000 pesos per hectare for each crop, with a cost for cultivation, etc., of approximately 300 pesos per hectare for each crop, yielding a gross profit of 700 pesos per hectare for each of the second and third crops. In other words, during a cycle of three and one-half to four years, or from the time of starting the preparation of the ground up to the harvesting of the third crop, the cost per hectare is approximately 1,300 pesos, the gross income is 3,200 pesos, and the gross profit is 1,900 pesos. From this profit must then be deducted the cost of tearing up and clearing the land in preparation for the second cycle. It has been

[2] One peso Philippine currency equals 50 cents United States currency.

found from experience that the land should either be allowed to lie fallow for a year or be planted with some cover crop rich in nitrogen, which should then be plowed under before replanting to pineapples is done. It is estimated that this process of tearing up and clearing the land after harvesting the last, or third crop, planting it in cover crops, and bringing it to the point of first plowing for an additional cycle of pineapples, will cost approximately 300 pesos per hectare which, deducted from the gross profit of 1,900 pesos, will show a gross profit of 1,600 pesos during a period of approximately five years, or an annual profit of 333 pesos per hectare. From this amount there should be deducted taxes, depreciation, and overhead.

The above figures were obtained from a company growing Smooth Cayenne pineapples for the Manila market and are assumed to represent conditions for pineapple growing in central Luzon at the present time.

Table 4,[3] showing the cost of setting out a hectare of pineapples, is also given as another estimate, made by the Bureau of Agriculture. Either estimate shows that growing the Smooth Cayenne for market purposes is decidedly the more profitable.

TABLE 4.—*Estimate of the outlay per hectare from the first year to the first harvest.*

Item.	Hawaiian pineapple plantation, Abucay.	Native pineapple plantation at Orion.
	Pesos.	*Pesos.*
Land	80.00	80.00
Clearing	250.00	50.00
Plants at 10 centavos (Hawaiian, 10,000 plants)	1,000.00	-----
Plants at 1 centavo (native, 20,000 plants)	-----	200.00
Plowing (three times)	37.90	-----
Harrowing (three times)	18.00	-----
Planting (Hawaiian, 1 by 1 meter)	18.00	-----
Planting (native, 1 by 0.5 meter)	-----	30.50
Cultivation and weeding for two years	300.00	-----
Weeding alone (once a year for two years)	-----	28.50
Irrigation and drainage twice a month during the dry season, for two years	65.00	-----
Harvesting (Hawaiian, 9,000 fruits)	27.00	-----
Harvesting (native, 15,000 fruits)	-----	54.00
Packing and packing materials	130.00	-----
Hauling	66.00	26.40
Shipping	30.00	35.00
Miscellaneous expenses	100.00	30.00
Total expenses	2,121.90	534.70

[3] Philip. Agr. Rev. No. 1, 18 (1925).

Smooth Cayenne pineapples are grown near Manila by the single-row method in well-drained reddish clay loam and in mixed alluvial and sedentary soil of basaltic and andesitic origin.

Near Manila there are two distinct seasons, a dry and a rainy season; dry in winter and spring, wet in summer and autumn. Only the summer rainfall prevails, the other being scarcely noticeable. Father José C. Coronas, chief of the meteorological division, Philippine Weather Bureau, states that, strictly speaking, by a dry month in the Philippines should be understood a month with less than 50 millimeters of rain; yet sometimes a month with even more than 100 millimeters is considered a dry month, especially if it comes after three or more very dry months. The average annual rainfall ranges from 1,800 to 2,500 millimeters.

Pineapples show favorable growth not only in places that have a dry and a wet season, but also in regions of the Philippines where no distinctive dry season occurs but where there is a pronounced maximum rainy period in winter; in places with no very pronounced maximum rain period and a short dry season lasting only one to three months; and in regions of no pronounced maximum rain period but no dry season, such as certain parts of Tayabas, Basilan, Jolo, Leyte, and a great portion of Mindanao.

Table 5 gives figures of rainfall [4] in districts claimed to be especially adapted to pineapple growing in the Philippines.

TABLE 5.—*Mean annual rainfall in localities in the Philippines adapted to pineapple growing.*

Month.	Isabela, Basilan.	Jolo, Sulu.	Cotabato, Cotabato.	Ormoc, Leyte.	Tayabas, Tayabas.	Santa Cruz, Laguna.
	mm.	mm.	mm.	mm.	mm.	mm.
January	54.5	89.1	98.8	176.7	135.1	64.4
February	89.2	122.4	88.8	100.7	42.2	47.3
March	58.2	85.2	68.1	78.3	60.2	38.1
April	89.2	118.2	164.9	65.8	23.8	48.4
May	108.0	160.2	218.5	72.8	99.3	131.8
June	210.6	203.3	237.3	177.2	83.8	145.0
July	208.4	172.0	292.0	324.8	96.6	306.2
August	205.8	170.4	271.8	288.0	93.9	289.3
September	201.6	184.4	248.6	308.5	116.5	267.2
October	261.7	222.9	255.1	257.5	239.0	245.7
November	168.4	193.0	231.7	219.6	283.2	183.8
December	138.6	144.8	133.5	180.7	195.4	123.9
Total	1,794.1	1,865.9	2,309.1	2,250.7	1,449.0	1,891.1

[4] Bureau of Agriculture Circular No. 16.

In a study of the area in the Philippines planted to Smooth Cayenne pineapples it was found that not more than 50 hectares produced fruit for the market during the past season of 1927. There are definite prospects of the area being greatly increased in the near future.

Specimens selected for analysis during the season of April to July amounted to 685, consisting of 376 Smooth Cayenne pineapples, 105 Smooth Cayenne cores, 129 native pineapples, and 75 native pineapple cores.

All of the Smooth Cayenne and many of the native varieties of fruits used for these analyses were picked from fields of known age and were analyzed within twenty-four hours after picking. There were a few fruits that were allowed to stand in the laboratory for ripening for specific determinations. As nearly as possible uniformity of ripeness was maintained in selecting these fruits.

The following explanations are given to permit clear interpretation of the tables found in this article:

Total weight.—The figures for total weight indicate the weight of the fruit after all parts of the crown and stem had been removed.

Percentage of edible portion.—By edible portion we mean the part of the pineapple remaining after cutting off the skin, the outer portions of the base, and the crown to the extent where no traces of the color of the fiber of the outer portions remain on the fruit. The edible portions were prepared for analysis by passing the whole portions, less the cores, through a large-sized meat grinder in such a manner as to lose none of the juice. Thus a true composite of the whole fruit or fruits was obtained, any possible error due to variations in composition of sections having been eliminated.

Percentage of waste.—The percentage of waste indicates the portion that had been removed from the fruit, not including the crown or any portion of the stem or the core.

The juice.—In all cases where analyses of juice were desirable a part or aliquot parts of the ground edible portion were taken, passed through a high-power basket centrifuge, and strained through muslin before determinations of Brix, total solids, sucrose, etc., were made.

Brix.—The Brix of the juice was determined by the use of spindles calibrated at the tropical temperature of 27.5° C. Brix is expressed as a corrected Brix for this temperature.

Total solids.—Determinations of the total solids were made directly by weighing and drying on a steam bath and then in an electric oven at 100 to 105° C., to constant weight.

All other analyses were made in accordance with the methods of the Association of Official Agricultural Chemists, with but few changes to suit tropical conditions.

Table 6 gives analyses of the juice and the edible portion of the native Philippine and the Smooth Cayenne pineapples obtained from various sources.

Thirty-nine fruits were purchased in the market places; no record to time of picking was obtainable. Reference to Table 6 shows the Brix, total sugars, total solids, percentage of fiber, protein, and ash of these fruits to be lower and the acidity higher than those of the remaining native specimens, which were taken directly from the plantations. The native fruits grown at Silang, Cavite, have a higher total solids and sugar content than have those grown at Guiguinto, Bulacan. This variation in composition is probably due not so much to soil and climate as to variation in the stock and to cultivation. Often the native pineapples are very poorly cultivated and the stock is greatly deteriorated. It is not believed that native pineapples kept in the Manila market for a week or ten days would show as great an increase in acidity by aging as is found in the case of the thirty-nine pineapples obtained from the Manila market. It is of interest that seven Smooth Cayenne pineapples obtained from Silang, analyses of which are found in Table 6, show a very close resemblance in composition to the analyses of twenty fruits of the native barrel-shaped, greenish yellow variety obtained from the same place. Investigation shows that these pineapples were large Smooth Cayenne pineapples obtained from deteriorated stock. Large attractive pineapples may be obtained from deteriorated stock planted under the best soil, climatic, and cultivation conditions, and yet such fruits when analyzed show their inferiority for canning or table purposes. As is the case with native pineapples, so it is with Smooth Cayenne grown in various localities; that is, the slight variations in composition are due probably more to differences in stock than to climatic and soil conditions. Cultivation and rainfall also seem to be strong factors that indirectly influence the composition of the ripening fruit. Ripening or ripe fruits that remain in the fields after the beginning of the rainy season are inferior in flavor to those harvested during the dry season.

The rich aroma seems to decrease rapidly, the fruits become less solid, and they taste less sweet. Fruits harvested after the rainy season has set in often show a low sucrose content, a change in the ratio between the sucrose and invert sugars, and an increase in acidity. Reference to the averages obtained from one hundred nine native and one hundred sixty-seven Smooth Cayenne fruits plainly shows the inferiority in size, content of sugars, acidity, fiber, and other factors of the native variety compared with the Smooth Cayenne. The Smooth Cayenne is larger, has a higher percentage of edible portion and less waste, is sweeter and less acid in taste, and has a higher content of inorganic salts, with a slightly higher alkalinity of its ash; also, the percentage of water is noticeably higher in the native varieties. The ratio between sucrose and invert sugars is, roughly, 2 : 1.

It may be stated that the average pineapple of Hawaiian stock grown near Manila or in the vicinity of central Luzon has a corrected Brix of about 14.80, a total sugar of about 13 per cent, and an acidity (as citric) of about 0.70 per cent. Since the Smooth Cayenne is the more important from the standpoint of suitability for table and canning purposes, very little reference to native fruits will be made hereafter in this paper.

In isolated cases Smooth Cayenne pineapples were found to have higher percentages of sucrose and invert sugars, and lower percentages of fiber and acidity than are expressed in Table 6 of composites. However, the averages indicate that these fruits have about the same content of sugars as have the Smooth Cayenne fruits grown in Florida and Hawaii, and slightly lower percentages of acidity. The expressed percentages of edible portion are much higher than those found in other places. This may be partly due to the fact that the crowns were not included in the total weight of the fruit rather than to the method of paring. Obviously, the low fiber content shown in the introduced Smooth Cayenne varieties indicates a better edible condition of the fruit. There is no great variation in composition of Smooth Cayenne pineapples grown in the various localities of central Luzon when the fruits are obtained from stocks that have not deteriorated.

Two groups of large and small ripe Smooth Cayenne pineapples were selected for analysis, to determine any differences that might occur in the chemical analyses of the juice and the edible portion due to size.

TABLE 6.—*Comparison of different varieties of ripe native pineapples and ripe Smooth Cayenne.*

Total fruit (less crown).				Juice analysis.							Edible portion.			
Fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix. 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.	Fiber.	Sucrose.
	g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
39	847	61.56	38.44	11.01	5.9	3.19	9.4	+5.0	—2.4	1.08	12.23	87.77	0.44	4.88
20	1,132	67.41	32.59	13.48	7.66	3.51	11.57	+6.9	—2.8	0.66	14.22	85.78	0.54	6.87
16	1,122	67.39	32.61	12.71	7.03	3.11	10.51	+6.3	—2.6	0.94	13.47	86.53	0.51	6.40
12	846	59.15	40.85	10.87	6.08	3.19	9.59	+5.5	—2.2	0.84	12.42	87.58	0.52	5.68
12	923	65.59	34.41	10.94	6.16	3.13	9.61	+5.6	—2.2	0.85	12.42	87.58	0.55	4.19
10	1,098	59.19	40.81	12.29	7.34	3.18	10.91	+6.8	—2.6	0.85	13.14	86.86	0.51	6.79
Average of 109 fruits	995	63.38	36.62	11.88	6.70	3.22	10.27	+6.0	—2.5	0.87	12.98	87.02	0.51	5.80
7	2,727	74.46	25.54	13.67	7.53	3.40	11.33	+6.6	—3.0	0.94	13.49	86.51	0.49	6.98
5	2,238	76.07	23.93	-------	9.17	4.41	14.06	+8.3	—3.4	0.74	15.90	84.10	-------	7.90
12	1,799	75.90	24.10	-------	8.53	4.41	13.38	+7.2	—3.6	0.67	15.88	84.12	0.45	8.45
9	2,639	77.21	22.79	15.02	8.39	4.78	13.61	+7.0	—3.6	0.57	15.51	84.49	0.54	6.89
6	2,204	76.46	23.54	15.88	8.94	4.28	13.69	+8.1	—3.2	0.60	16.50	83.50	0.37	8.23
12	2,223	75.24	24.76	15.57	9.31	4.55	14.35	+8.1	—3.6	0.61	16.59	83.41	0.55	8.16
1	3,062	78.48	21.52	15.53	9.22	4.21	13.91	+8.3	—3.4	0.57	16.17	83.83	0.40	8.43
4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	15.30	84.70	0.45	7.83
10	3,565	69.54	30.46	14.84	8.58	5.00	14.03	+7.8	—3.2	0.78	15.65	84.35	0.47	7.57
10	2,793	70.10	29.90	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	15.47	84.53	0.52	7.62
13	1,593	71.90	28.10	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	16.46	83.54	0.46	8.87
10	2,865	71.63	28.37	14.11	8.01	4.32	12.74	+6.8	—3.4	0.67	-------	-------	0.48	6.59
9	2,319	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65	0.44	6.61
16	2,354	76.52	23.48	14.57	7.88	3.75	12.04	+7.2	—2.8	0.59	14.82	85.18	0.40	7.08
10	3,123	70.50	29.50	14.31	7.38	4.55	12.33	+6.0	—3.4	0.74			0.46	6.51
10	2,488	76.50	23.50	14.01	7.95	3.78	12.15	+6.7	—3.4	0.92	-------	-------	0.47	6.69
23	2,673	75.71	24.29	14.88	7.64	4.59	12.63	+6.3	—3.4	0.74	15.21	84.79	0.49	7.08
Average of 167 fruits	2,567	74.41	25.56	14.82	8.38	4.21	13.01	+7.3	—3.3	0.70	15.59	84.41	0.47	7.50

Total fruit (less crown).				Edible portion.						
Fruits.	Average weight.	Edible portion.	Waste.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Variety, shape, color, source.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
39	847	61.56	38.44	3.16	8.30	0.95	0.45	0.41	0.15	Native; barrel; orange; Manila markets.
20	1,132	67.41	32.59	3.40	10.63	0.62	0.49	0.50	0.16	Native; barrel; greenish yellow; Silang.
16	1,122	67.39	32.61	3.01	9.75	0.58	0.48	0.42	0.14	Native; cylindrical; orange red; Silang.
12	846	59.15	40.85	3.04	9.02	0.72	0.50	0.45	0.14	Native (costa); cylindrical; orange red; Guiguinto.
12	923	65.59	34.41	3.04	7.45	0.75	0.49	0.49	0.17	Native; barrel; greenish yellow; Guiguinto.
10	1,098	59.19	40.81	2.68	9.83	0.73	0.47	0.49	0.15	Native; cylindrical; green (ripening stage); Silang.
Average of 109 fruits	995	63.38	36.62	3.06	9.16	0.73	0.48	0.46	0.15	
7	2,727	74.46	25.54	3.09	10.44	0.78	0.47	0.52	0.15	Smooth Cayenne; Silang.
5	2,238	76.07	23.93	3.57	11.93	0.66	0.38	0.53	0.23	Smooth Cayenne; Laguna.
12	1,799	75.90	24.10	3.98	12.87	0.63	0.33	0.54	0.22	Smooth Cayenne; Bataan.
9	2,639	77.21	22.79	4.89	12.15	0.46	0.39	0.60	0.26	Smooth Cayenne; Laguna.
6	2,204	76.46	23.54	3.81	12.47	0.49	0.41	0.50	0.19	Smooth Cayenne; Bataan.
12	2,223	75.24	24.76	4.43	13.02	0.51	0.39	0.57	0.24	Do.
1	3,062	78.48	21.52	4.18	13.05	0.47	0.39	0.48	0.18	Do.
4	2,979	77.81	22.19	3.72	11.96	0.54	0.42	0.61	0.22	Do.
10	3,565	69.54	30.46	4.90	12.87	0.69	0.41	0.56	0.22	Smooth Cayenne; Laguna.
10	2,793	70.10	29.90	3.95	11.97	0.56	0.41	0.64	0.25	Do.
13	1,593	71.90	28.10	3.83	13.17	0.58	0.37	0.71	0.27	Do.
10	2,865	71.63	28.37	3.83	10.77	--------	0.57	0.51	0.20	Do.
9	2,319	71.51	28.49	3.77	10.73	--------	0.48	0.68	0.24	Do.
16	2,354	76.52	23.48	3.67	11.12	0.54	0.39	0.67	0.22	Do.
10	3,123	70.50	29.50	4.25	11.10	--------	0.53	0.50	0.19	Do.
10	2,488	76.50	23.50	3.68	10.70	--------	0.54	0.66	0.23	Do.
23	2,673	75.71	24.29	4.51	11.96	0.55	0.45	0.77	0.23	Do.
Average of 167 fruits	2,567	74.44	25.56	4.00	11.90	0.57	0.43	0.59	0.22	

Table 7 gives the analyses of the two groups mentioned and the average of the twenty-three fruits used. The percentage of edible portion is found to be slightly larger in smaller fruits; while the ratio of sucrose to invert sugars remains approximately 2 : 1 in the larger fruits, it is somewhat disturbed in favor of sucrose in the smaller fruits. The higher percentages of edible portion, sucrose, total sugars as invert, and the lower percentages of fiber indicate that the smaller fruits are pleasanter to the taste. The smaller fruits show a higher acidity than do the larger ones. Table 7 tends to illustrate the fact that the largest fruits are not always the best for canning and for table purposes.

A portion of the field was partially shaded during the plowing season. The shade was produced by placing a thin layer of coconut leaves on a frame 2.5 meters above a section of the field.

Table 8 shows the analyses of these two groups. There are no consistent variations in these figures. Apparently partial shading from the beginning of the flowering stage to ripening does not materially affect the composition or the size of the fruit.

Fruits were selected as near as possible to the age expressed in Table 9, and analyzed to find the variations in composition following growth from one month to five months of age. With growth there is a concomitant increase in weight and percentage of edible portion of the total fruit with a decrease in percentage of waste. The juice analyses show a gradual increase in Brix, sucrose, invert sugars, and acidity. Moisture and percentage of fiber in the edible portion decrease with growth and ripening. Obviously the total solids of the edible portion increase along with the total sugars. From the age of one month to full growth or maturity, the juice increases from 0.78 per cent sucrose to 8.69 per cent, with an approximate increase of 1 per cent sucrose in ripening. During a period of three and one-half to four months the juice increases from 0.22 acidity to 0.79 per cent.

Equal numbers of mature yellow and green Smooth Cayenne pineapples were selected from a shipment, and analyses were made of the two groups to determine whether or not the color of the fruit can be used as a criterion of ripeness. Fruits were selected as nearly as possible of the same size, firmness, and weight; four were entirely green, and four others yellow or orange.

TABLE 7.—*Analyses of large and small ripe Smooth Cayenne pineapples from Laguna Province.*

Total fruit (less crown).				Juice analysis.							Edible portion.	
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
10	2,793	70.10	29.9	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	15.47	84.53
13	1,593	71.90	28.1	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	16.46	83.54
Average of 23 fruits	2,193	71.00	29.0	15.42	8.84	3.95	13.25	+8.0	—3.3	0.69	15.97	84.04

Total fruit (less crown).				Edible portion.								Size.
Number of fruits.	Average weight.	Edible portion.	Waste.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
10	2,793	70.10	29.9	0.52	7.62	8.95	11.97	0.56	0.41	0.64	0.25	Large.
13	1,593	71.90	28.1	0.46	8.87	3.83	13.17	0.58	0.37	0.71	0.27	Small.
Average of 23 fruits	2,193	71.00	29.0	0.49	8.25	3.89	12.57	0.57	0.39	0.68	0.26	

TABLE 8.—*Analyses of ripe Smooth Cayenne pineapples growing in the shade and exposed to direct sunshine.*

Total fruit (less crown).				Juice analysis.							Edible portion.	
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
10	3,123	70.50	29.50	14.31	7.38	4.55	12.33	+6.0	—3.4	0.74		
10	2,488	76.50	23.50	14.01	7.95	3.78	12.15	+6.7	—3.4	0.92		
23	2,673	75.71	24.29	14.88	7.64	4.59	12.63	+6.3	—3.4	0.74	15.21	84.79
Average of 43 fruits	2,761	74.24	25.76	14.40	7.66	4.31	12.37	+6.3	—3.4	0.80		
10	2,865	71.63	28.37	14.11	8.01	4.32	12.74	+6.8	—3.4	0.67		
9	2,319	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65
16	2,354	76.52	23.48	14.57	7.88	3.75	12.04	+7.2	—2.8	0.59	14.82	85.18
Average of 35 fruits	2,513	73.22	26.78	14.72	7.82	3.97	12.19	+6.7	—3.2	0.67		

Total fruit (less crown).				Edible portion.								
Number of fruits.	Average weight.	Edible portion.	Waste.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash. K_2CO_3.	Shaded or exposed.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
10	3,123	70.50	29.50	0.46	6.51	4.25	11.10		0.53	0.50		Shaded.
10	2,488	76.50	23.50	0.47	6.69	8.68	10.70		0.54	0.66	0.23	Do.
23	2,673	75.71	24.29	0.49	7.08	4.51	11.96	0.55	0.45	0.77	0.23	Do.
Average of 43 fruits	2,761	74.24	25.76	0.47	6.76	4.15	11.25		0.51	0.64		Shaded.
10	2,865	71.63	28.37	0.48	6.59	3.83	10.77		0.57	0.51		Exposed.
9	2,319	71.51	28.49	0.44	6.61	3.77	10.73		0.48	0.68	0.24	Do.
16	2,354	76.52	23.48	0.40	7.08	3.67	11.12	0.54	0.39	0.67	0.22	Do.
Average of 35 fruits	2,513	73.22	26.78	0.44	6.76	3.76	10.87		0.48	0.62		Exposed.

TABLE 9.—*Showing changes in composition with the growth of Smooth Cayenne fruits.*

Total fruit (less crown).				Juice analysis.							Edible portion.		
Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.	Fiber.
	g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	P. ct.	P. ct.	P. ct.
20	541	62.34	37.66	6.58	0.78	2.63	3.45	+0.4	—0.6	0.22	7.14	92.86	0.80
10	1,843	69.65	30.35	6.11	2.37	2.26	4.75	+2.2	—0.8	0.37	7.89	92.11	0.56
10	438	60.85	39.15	7.84	2.21	2.75	5.08	+2.2	—0.6	0.50	9.04	90.96	0.56
20	1,183	67.74	32.26	7.04	3.28	2.58	6.03	+3.2	—1.0	0.53	8.70	91.30	0.52
10	2,664	71.09	28.91	7.61	3.41	2.65	6.24	+3.3	—1.0	0.48	9.38	90.62	0.58
10	1,420	68.25	31.75	10.34	5.37	2.68	8.33	+5.2	—1.6	0.67	10.95	89.05	0.54
2	2,017	70.74	29.26	10.01	6.00	2.96	9.27	+5.2	—2.4	0.78	11.62	88.38	0.49
2	2,486	72.19	27.81	12.04	6.72	3.63	10.70	+6.1	—2.4	0.85	13.15	86.85	0.47
9	2,208	71.51	28.49	14.48	7.56	3.83	11.79	+6.2	—3.4	0.75	15.35	84.65	0.44
4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	15.30	84.70	0.45
9	2,639	77.21	22.79	15.02	8.39	4.78	13.61	+7.0	—3.6	0.57	15.51	84.49	0.54
12	2,223	75.24	24.76	15.57	9.31	4.55	14.35	+8.1	—3.6	0.61	16.59	83.41	0.55
2	2,576	75.74	24.26	15.37	9.65	4.72	14.88	+8.2	—4.0	0.79	16.31	--------	0.47

TABLE 9.—*Showing changes in composition with the growth of Smooth Cayenne fruits*—Continued.

Total fruit (less crown).				Edible portion.								
Number of fruits.	Average weight.	Edible portion.	Waste.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Age.	Source.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*Months.*	
20	541	62.34	37.66	0.63	2.53	3.19	0.22	0.55	0.70	0.37	1–1.5	Laguna.
10	1,843	69.65	30.35	2.14	2.19	4.44	0.27	0.40	0.51	0.21	2	Do.
10	438	60.85	39.15	1.89	2.58	4.57	0.31	0.49	0.72	0.35	2	Lamao.
20	1,183	67.74	32.26	3.05	2.56	5.77	0.39	0.35	0.50	0.15	2.5	Laguna.
10	2,664	71.09	28.91	3.08	2.55	5.79	0.36	0.39	0.54	0.22	3–3.5	Do.
10	1,420	68.25	31.75	4.58	2.63	7.50	0.53	0.37	0.54	0.20	3–3.5	Bataan.
2	2,017	70.74	29.26	5.53	2.93	8.75	0.61	0.35	0.51	0.18	3–3.5	Silang.
2	2,486	72.19	27.81	6.32	3.45	10.10	0.65	0.38	0.58	0.20	4	Do.
9	2,208	71.51	28.49	6.61	3.77	10.73	--------	0.48	0.68	0.24	4	Laguna.
4	2,979	77.81	22.19	7.83	3.72	11.96	0.54	0.42	0.61	0.22	4	Bataan.
9	2,639	77.21	22.79	6.89	4.89	12.15	0.46	0.39	0.60	0.26	4.5–5	Laguna.
12	2,223	75.24	24.76	8.16	4.43	13.02	0.51	0.39	0.57	0.24	4.5–5	Bataan.
2	2,576	75.74	24.26	8.86	4.51	13.84	0.62	0.34	0.53	0.17	4.5–5	Silang.

TABLE 10.—*Analyses of the juice of green fruits and yellow fruits (Smooth Cayenne) from Bataan Province.*

Color.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		
Green	7.82	3.44	11.77	0.72	+7.1	—2.8
Do	8.29	4.18	12.91	0.63	+7.5	—3.0
Do	8.30	4.25	12.99	0.61	+7.3	—3.2
Do	9.56	4.28	14.34	0.69	+8.7	—3.4
Average	8.49	4.04	13.00	0.66	+7.7	—3.1
Yellow	7.35	3.49	11.13	0.69	+6.7	—2.6
Do	7.98	4.21	12.61	0.62	+7.1	—3.0
Do	8.61	4.25	13.31	0.54	+7.1	—3.8
Do	9.87	4.25	14.64	0.65	+8.9	—3.6
Average	8.45	4.05	12.92	0.62	+7.45	—3.3

Table 10 shows no important differences in the composition of the two groups. The figures indicate that the green color of a pineapple is not always a true indication of its immaturity or lack of ripeness.

Six pineapples, having an average weight of 2,980 grams, with 75.63 per cent of edible portion and 24.37 per cent of waste, were halved as nearly vertically as possible into green and yellow halves, and the edible portion of each half was separately analyzed for sugars and acidity.

TABLE 11.—*Sugars and acidity in green and yellow halves of Smooth Cayenne pineapples, halved vertically.*

Half.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*		
Yellow side	8.77	4.25	13.48	0.49	+7.1	—4.0
Green side	9.16	4.32	13.96	0.41	+7.6	—4.0
Yellow side	7 34	4.67	12.40	0.44	+6.3	—3.0
Green side	7.74	4.72	12.87	0.50	+6.6	—3.2
Yellow side	7.58	4.47	12.45	0.51	+6.2	—3.4
Green side	8.53	4.51	13.49	0.52	+7.4	—3.4
Yellow side	9.01	4.95	14.43	0.43	+7.4	—4.0
Green side	8.68	4.90	14.04	0.44	+7.2	—3.8
Yellow side	8.77	4.72	13.95	0.46	+7.3	—3.8
Green side	8.85	4.72	14.03	0.49	+7.4	—3.8
Yellow side	8.37	3.83	12.56	0.61	+7.0	—3.6
Green side	7.82	3.86	12.09	0.61	+6.5	—3.4
Average yellow	8.31	4.37	13.23	0.49	+6.9	—3.6
Average green	8.46	4.51	13.41	0.50	+7.1	—3.6

The highest sucrose was found in a green side and the highest invert sugars in a yellow side. The highest total sugar was found in a yellow side. The lowest acidity was found in a green side. The averages show slightly higher results in all cases for the green sides; the variations were not great enough to indicate inferiority of quality in either portion of average fruit. Not only do individual fruits vary greatly in sugar content and acidity, but also portions of the same fruit show variations in percentages.

Two composites of ten fruits each and five individual fruits were analyzed to determine the difference in sugars and acidity in the upper and lower halves when cut horizontally.

Table 12 shows the lower half of the fruit in both the composites and the individual fruits to contain consistently a higher percentage of sucrose and total sugars and a lower percentage of acidity, regardless of the source or the varieties of pineapples used. These factors, with the data obtained in the analyses of the cores, indicate that the sweetest portion of the pineapple (the part containing the highest percentage of sugars) is found in the center of the base of the edible portion. It is quite probable that the sugar content gradually decreases outward and upward from this point, while the acidity increases in the same directions.

One hundred eighty ripe fruits of three types of native pineapples and some Smooth Cayennes from various sources were analyzed in groups of composites as outlined in Table 13 in order to find if any variations existed in composition of the cores and of the edible portions.

The core of the native pineapple is in most cases so hard that it is not edible. It is regretted that the determination of fiber content was neglected in this work. However, it is quite obvious that the fiber content is much higher in the native pineapple than in the Smooth Cayenne. Juice analyses of a composite of an assortment of thirty-nine small native pineapples of indefinite storage in the Manila markets show the edible portion to be higher than the core in all determinations. The cylindrical fruit from Silang shows the edible portion to be higher in Brix, sucrose, and acidity, but lower in invert sugars and total sugars as invert, while the barrel-shaped fruit from the same place shows the edible portion to be higher in Brix, invert sugars, total sugars, and acidity, but lower in sucrose.

TABLE 12.—*Brix-sugars and acidity in upper and lower halves of pineapples.*

Number of fruits.	Part.	Juice analysis. Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.	Corrected Brix 27.5°C.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
1 {10	Upper	7.41	2.61	10.41	0.85	+6.1	—3.4	10.89
1 {10	Lower	7.96	2.77	11.16	0.85	+7.4	—2.8	12.69
Average		7.69	2.69	10.79	0.85	+6.8	—3.1	11.79
2 {10	Upper	6.64	3.44	10.43	0.87	+6.1	—2.4	12.67
2 {10	Lower	9.84	5.00	15.36	0.72	+9.0	—3.6	16.77
Average		8.24	4.22	12.90	0.80	+7.6	—3.0	14.72
3 {1	Upper							
3 {1	Lower							
4 {1	Upper							
4 {1	Lower							
5 {1	Upper							
5 {1	Lower							
6 {1	Upper							
6 {0	Lower							
7 {1	Upper							
7 {1	Lower							
Average Smooth Cayenne, Laguna	Upper							
	Lower							

TABLE 12.—*Brix-sugars and acidity in upper and lower halves of pineapples*—Continued.

Juice analysis.		Edible portion.						
Number of fruits.	Part.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Polarization direct.	Polarization invert.	Variety and source.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*			
1 { 10	Upper	5.93	2.56	8.8	0.75	+5.4	—2.8	Native.
1 { 10	Lower	7.65	2.52	10.57	0.71	+7.0	—2.8	Do.
Average		6.79	2.54	9.69	0.73	+6.2	—2.8	
2 { 10	Upper	5.93	2.27	8.51	0.75	+5.2	—2.4	Smooth Cayenne; Laguna.
2 { 10	Lower	9.21	4.95	14.64	0.63	+8.2	—3.6	Do.
Average		7.57	3.61	11.58	0.69	+6.7	—3.0	
3 { 1	Upper	6.96	3.98	11.31	0.57	+6.0	—2.6	Smooth Cayenne; Laguna.
3 { 1	Lower	8.85	4.39	13.71	0.38	+8.0	—3.2	Do.
4 { 1	Upper	6.01	3.72	10.05	0.63	+5.2	—2.4	Do.
4 { 1	Lower	8.93	4.32	13.72	0.44	+8.1	—3.2	Do.
5 { 1	Upper	6.64	3.69	10.68	0.63	+6.0	—2.4	Do.
5 { 1	Lower	9.17	4.43	14.08	0.44	+8.0	—3.4	Do.
6 { 1	Upper	6.88	3.92	11.16	0.61	+6.1	—2.6	Do.
6 { 1	Lower	10.20	4.40	15.14	0.42	+8.3	—3.6	Do.
7 { 1	Upper	7.03	3.69	11.09	0.68	+6.1	—2.8	Do.
7 { 1	Lower	9.49	4.18	14.17	0.48	+8.4	—3.6	Do.
Average Smooth Cayenne, Laguna.	Upper	6.7	3.8	10.86	0.62	+5.88	—2.56	
	Lower	9.33	4.34	14.96	0.43	+8.16	—3.40	

TABLE 13.—*Analyses of juices of cores of ripe pineapples with composition of edible portions.*

Total fruit (less crown).					Juice analysis.							Class, shape, color, and source.
Part.	Number of fruits.	Average weight.	Edible portion.	Waste.	Corrected Brix at 27.5° C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	
		g.	P. ct.	P. ct.		P. ct.	P. ct.	P. ct.			P. ct.	
Core	39	847	61.56	38.44	9.61	4.95	3.09	8.3	+4.3	—2.0	0.75	Native; barrel; orange; Manila markets.
Edible portion	39	847	61.56	38.44	11.01	5.9	3.19	9.4	+5.0	—2.4	1.08	Do.
Core	16	1,122	67.39	32.61	11.58	6.95	3.23	10.55	+6.2	—2.6	0.43	Native; cylindrical; orange red; Silang.
Edible portion	16	1,122	67.39	32.61	12.71	7.01	3.11	10.49	+6.3	—2.6	0.94	Do.
Core	20	1,132	67.41	32.59	13.38	7.82	3.27	11.50	+7.3	—2.6	0.58	Native; barrel; greenish yellow; Silang.
Edible portion	20	1,132	67.41	32.59	13.48	7.66	3.51	11.57	+6.9	—2.8	0.66	Do.
Core	4	2,979	77.81	22.19	12.44	8.43	2.24	11.11	+7.6	—3.2	0.80	Bataan.
Edible portion	4	2,979	77.81	22.19	14.53	8.68	3.78	12.65	+7.8	—3.4	0.67	Do.
Core	35	2,513	73.22	26.78	14.01	8.96	3.31	12.74	+8.4	—3.0	0.38	Laguna; exposed Smooth Cayenne.
Edible portion	35	2,513	73.22	26.78	14.72	7.82	3.97	12.19	+6.7	—3.2	0.67	Do.
Core	43	2,761	74.24	25.76	13.74	8.65	3.49	12.59	+8.0	—3.0	0.41	Laguna; shaded Smooth Cayenne.
Edible portion	43	2,761	74.24	25.76	14.40	7.66	4.31	12.37	+6.3	—3.4	0.80	Do.
Core	10	2,793	70.10	29.9	13.91	9.05	3.44	12.96	+9.0	—3.4	0.31	Laguna; large Smooth Cayenne.
Edible portion	10	2,793	70.10	29.9	15.04	8.16	4.04	12.63	+7.4	—3.0	0.61	Do.
Core	13	1,593	71.90	28.1	14.64	10.12	3.31	13.96	+9.3	—3.6	0.32	Laguna; small Smooth Cayenne.
Edible portion	13	1,593	71.90	28.1	15.80	9.51	3.86	13.87	+8.5	—3.6	0.76	Do.

Apparently the native varieties are not consistent in their variations in the composition of the core and of the edible portion, even when the fruits are obtained from the same source and as nearly as possible in the same condition of ripeness.

Although only four Smooth Cayenne pineapples were obtainable from Bataan, yet it is interesting to note that the composite edible portion of these has a higher Brix, sucrose, invert sugar, total sugar, and lower acidity than has the core. On the other hand, Smooth Cayenne pineapples obtained from Laguna, both those grown under shade and those exposed, and also the large and small fruits, consistently show an edible portion having a juice of higher Brix reading, lower sucrose content, lower total sugars as invert, and higher percentages of invert sugars and acidity. This indicates that from the core to the outer portion of the fruit there is a gradual increase in Brix, invert sugars, and acidity, and a decrease in sucrose content of the juice.

The cores of the Smooth Cayenne are more succulent and sweeter than are those of the native varieties. When the hard native cores are compared with the soft, sweet ones of the Smooth Cayenne and the quantity of core remaining in the slices of canned pineapple is considered, it seems rather doubtful that a hybrid of these two varieties would be a highly suitable product for canning purposes from the standpoint of edibility of the remaining core. The analyses and taste indicate that the barrel-shaped greenish yellow variety would be the most acceptable of the three classes of native pineapple as to flavor.

A brown rot caused in the fruitlets of Smooth Cayenne pineapples by an undescribed yellow facultative anaërobe has been reported by Mr. F. Serrano, of the coöperative plant pathology laboratory, Bureau of Science and Bureau of Agriculture. The fruits used in his investigation were analyzed as part of this work. During the progress of our analyses we noticed that as the rainy season progressed the diseased condition of the fruit appeared to develop more rapidly; that is, the area of disease in the fruits was more extensive and pronounced at this time than in fruits cut during the dry season.

Table 14 shows analyses of forty-one fruits at different stages of the disease. The sucrose content in the badly diseased fruits varies from 8.53 to 10.29 per cent. A comparison of Tables 6 and 14 and their averages shows that the composition of the diseased and the sound healthy fruits of approximately the same

TABLE 14.—*Analyses of diseased Smooth Cayenne pineapples.*

Number of fruits.	Total fruit (less crown). Average weight.	Edible portion.	Waste.	Juice analysis. Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert.	Polarization direct.	Polarization invert.	Acidity as citric.	Edible portion. Total solids.	Moisture.	Fiber.	Sucrose.
	g.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7	1,550	74.09	25.91	15.01	8.53	4.59	13.56	+7.2	—3.6	0.74	15.97	84.03	0.47	8.21
5	2,428	78.05	21.95	15.26	8.15	4.92	13.50	+7.1	—3.2	0.64	16.12	83.88	0.53	7.75
12	2,162	74.05	25.95	15.43	8.79	4.59	13.84	+7.7	—3.4	0.65	16.67	83.33	0.47	7.92
13	2,802	75.39	24.61	15.86	7.99	5.33	13.74	+6.4	—3.7	0.67	16.42	83.58	0.52	7.32
1	2,138	73.99	26.01	16.38	10.29	4.55	15.38	+9.2	—3.8	0.63	17.72	82.28	0.48	9.58
3				14.44	8.53	4.01	12.99	+7.3	—3.4	0.73	15.33	84.67	0.50	7.51
Average of 41 diseased fruits	2,216	75.11	24.89	15.40	8.71	4.67	13.84	+7.5	—3.5	0.68	16.37	83.63	0.50	8.05
Average of 167 sound fruits	2,567	74.44	25.56	14.82	8.38	4.21	13.01	+7.3	—3.3	0.70	15.59	84.41	0.47	7.50

Number of fruits.	Total fruit (less crown). Average weight.	Edible portion.	Waste.	Edible portion. Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.	Condition of disease.	Source.
	g.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*			
7	1,550	74.09	25.91	4.16	12.80	0.70	0.33	0.57	0.22	Slight	Bataan.
5	2,428	78.05	21.95	4.79	12.95	0.46	0.40	0.59	0.25	do	Laguna.
12	2,162	74.05	25.95	4.25	12.58	0.55	0.34	0.48	0.19	do	Bataan.
13	2,802	75.39	24.61	4.93	12.63	0.60	0.41	0.63	0.27	Diseased	Laguna.
1	2,138	73.99	26.01	4.51	14.59	0.52	0.37	0.54	0.20	Badly diseased	Bataan.
3				3.98	11.99	0.42	0.34	0.53	0.19	do	Laguna.
Average of 41 diseased fruits	2,216	75.11	24.89	4.44	12.92	0.54	0.37	0.56	0.22	Diseased	Average.
Average of 167 sound fruits	2,567	74.44	25.56	4.00	11.90	0.57	0.43	0.59	0.22	Sound	Do.

condition of ripeness does not differ sufficiently to indicate any marked depreciation in the quality or flavor of the fruit. The averages show no great consumption of sugars or increase in acidity that might be attributed to the action of the bacteria.

Variations in composition of healthy and of diseased halves of ripe Smooth Cayenne pineapples are not sufficiently great to be attributed to any factor other than the natural variations in composition of the fruits, or in parts of the fruits. It is almost impossible to select diseased pineapples without cutting them. Consequently it was found necessary to utilize such material as was available for this work.

Although the fruits were mature and for all practical purposes ripe, it is quite possible that some of the specimens analyzed in Table 15 possessed green and yellow surfaces. Consequently slightly larger differences in composition are probably due to the naturally varying content of sugars and acidity in such halves (Table 16).

Only the diseased spots were cut from four badly diseased fruits and analyses made of the healthy and the diseased parts, to determine whether the fruit mass actually in contact with the disease showed any great change in composition attributable to bacterial action. The area in intimate contact with the disease gives a juice of lower Brix reading, lower percentages of sugars, acidity, fiber, total solids, and protein, with higher moisture and ash percentages. Considering the slight differences in the acidity and the higher purity of the juice of the diseased parts, it may be inferred that the juice of the diseased portion is not inferior in flavor to that of the healthy portion, unless the bacteria themselves impart a distinctive flavor to the fruit. Diseased sections were tasted and no difference in flavor was observed. It seems plausible to conclude that the disease injures the value of the fruit from the standpoint of appearance rather than by any change in chemical composition.

A search of available literature for data from other countries for comparative purposes resulted in the following incomplete table (Table 17).

The difference in the percentages of edible portion may be due to the fact that the crowns were not included as a portion of the fruit in our analyses. Table 17 shows a marked difference in the percentages of protein. No doubt, if averages were now obtained on the same numbers of Smooth Cayenne pine-

TABLE 15.—*Analyses of diseased and healthy halves of the same pineapples (Smooth Cayenne, from Laguna) halved vertically.*

Total fruit (less crown).		Juice analysis.							Edible portion.	
Number of fruits.	Half.	Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as inverts.	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids.	Moisture.
			P. ct.	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
4	Healthy	13.48						0.68	14.14	85.86
	Diseased	14.21						0.67	15.27	84.73
2	Healthy	14.54	8.36	3.49	12.29	+7.4	—3.2	0.57	15.07	84.93
	Diseased	14.94	8.66	3.75	12.86	+7.8	—3.2	0.56	15.67	84.33
4	Healthy	15.27	9.13	3.75	13.36	+8.2	—3.4	0.57	15.81	84.19
	Diseased	13.14	7.08	3.80	11.25	+6.0	—3.0	0.48	13.74	86.26
1	Healthy								16.88	
	Diseased									
Average healthy		14.43	8.75	3.62	12.83	+7.8	—3.3	0.61	15.48	84.99
Average diseased		14.09	7.87	3.78	12.06	+6.9	—3.1	0.57	14.87	85.11

Total fruit (less crown).		Edible portion.							
Number of fruits.	Half.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
4	Healthy	0.42	6.45	4.17	10.96		0.50	0.62	0.21
	Diseased	0.41	6.45	4.14	10.93		0.55	0.71	0.25
2	Healthy	0.35	7.2	3.42	11.04	0.34	0.42	0.76	0.22
	Diseased	0.46	8.18	3.69	12.30	0.48	0.47	0.72	0.21
4	Healthy	0.45	7.71	3.64	11.76	0.48	0.38	0.65	0.21
	Diseased	0.47	6.53	3.75	10.62	0.40	0.36	0.64	0.20
1	Healthy	0.47	9.25	4.55	14.29	0.38	0.34	0.63	0.20
	Diseased	0.39	7.90	4.14	12.46	0.39	0.32	0.59	0.21
Average healthy		0.42	7.65	3.95	12.01	0.40	0.41	0.66	0.21
Average diseased		0.43	7.27	3.93	11.58	0.42	0.43	0.67	0.22

TABLE 16.—*Analyses of diseased and healthy portions of the same pineapples.*

Total fruit (less crown).		Juice analysis.							Edible portion.	
Number of fruits.	Part.	Corrected Brix at 27.5°C.	Sucrose.	Invert sugars.	Total sugars as invert	Polarization direct.	Polarization invert.	Acidity as citric.	Total solids	Moisture.
			P. ct.	*P. ct.*	*P. ct.*			*P. ct.*	*P. ct.*	*P. ct.*
4	Healthy	16.04	8.79	4.51	13.77	+8.0	—3.2	0.49	16.76	83.24
4	Diseased	13.84	8.55	4.32	13.32	+7.7	—3.2	0.45	13.71	86.29

Total fruit (less crown).		Edible portion.							
Number of fruits.	Part.	Fiber.	Sucrose.	Invert sugars.	Total sugars as invert.	Acidity as citric.	Protein (Nx6.25).	Ash.	Alkalinity of ash K_2CO_3.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
4	Healthy	0.45	7.85	4.43	12.69	0.43	0.38	0.75	0.26
4	Diseased	0.40	7.85	4.25	12.51	0.39	0.37	0.88	0.30

TABLE 17.—*Comparison of analyses of Smooth Cayenne pineapples grown in Florida, Hawaii, and the Philippines.*

Source.	Variety.	Edible portion.	Waste.	Sucrose.	Invert sugars.	Acidity as citric.	Ash.	Protein (Nx6.25).
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Florida (1 sample) [a]	Smooth Cayenne	62.8	37.2	8.86	4.05	0.85	0.42	0.56
Hawaiian (19 samples) [b]	do			7.88	4.23	1.05	----------	0.50
Philippines (167 samples)	do	71.41	25.56	8.38	4.21	0.73	0.59	0.43

[a] Data from H. H. Hume, Bul. 70, Florida Agr. Exp. Sta. [b] Data from W. P. Kelley, Laboratory of Hawaiian Exp. Sta., Paper No. 3.

apples grown in Hawaii, Florida, and the Philippines, such averages would show very close resemblance to each other.

SUMMARY AND CONCLUSIONS

1. The growth of pineapple culture in central Luzon is briefly outlined.

2. Figures are given showing the cost of planting a hectare, harvesting and placing the pines on the Manila market, and the net profits therefrom.

3. The methods of grading and the approximate percentages of each grade obtainable, per hectare, are given, with the wholesale price per crate of each grade.

4. Climate and soil conditions are discussed.

5. Smooth Cayenne and native pineapples are described and their differences in chemical composition shown.

Tabulated analyses are given showing:

(*a*) Variations in composition with size of the fruit.
(*b*) Composition of shaded and exposed fruits.
(*c*) Changes in composition with growth of the fruit.
(*d*) Composition of the juices of mature green and mature yellow fruits.
(*e*) Variations in composition of green and of yellow halves of the same fruits, halved vertically.
(*f*) Variations in composition of upper and lower halves of the same fruits.
(*g*) Variations in composition between the cores and the edible portions of the same fruits.
(*h*) Composition of diseased fruits and a comparison of determinations made on diseased portions with healthy portions of the same fruits.
(*i*) Composition of Smooth Cayenne pineapples grown in Florida, Hawaii, and the Philippines.
(*j*) Composition of fruits grown from deteriorated stock.

The Smooth Cayenne is the accepted best variety grown in the Philippines for table and canning purposes. The average ripe fruit of this type grown from stock introduced from Hawaii has approximately a corrected Brix reading of 14.80, total sugars as invert of about 13 per cent, and an acidity as citric of about 0.70 per cent.

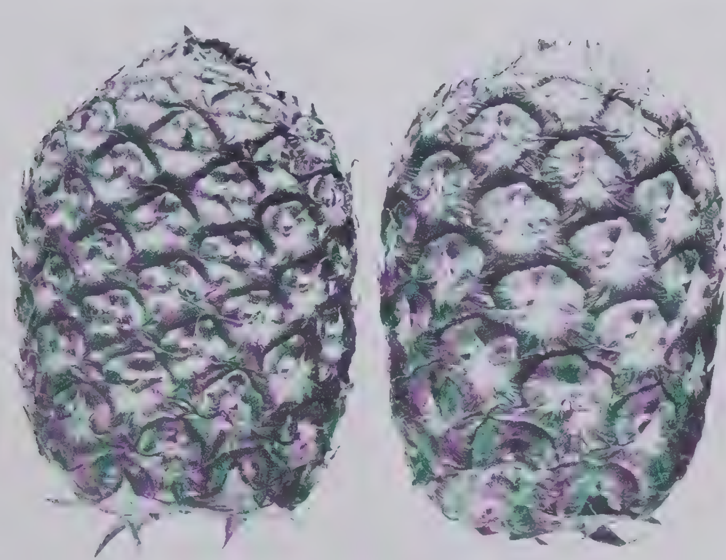
Fruits ripening during the rainy season in central Luzon rapidly decrease in aroma and become less solid and inferior

in flavor with a concomitant increase in area of infection from an undescribed bacterium.

One of the oldest plantations reports the percentage of infected fruits to be not over 1 to 2 per cent.

With proper precautions in the selection of stock and soil and with good cultivation and care, Smooth Cayenne pineapples of uniformly fine quality, practically free from disease, should be obtained in the Philippines with high percentages of yields and with low costs for land and for labor.

ILLUSTRATIONS



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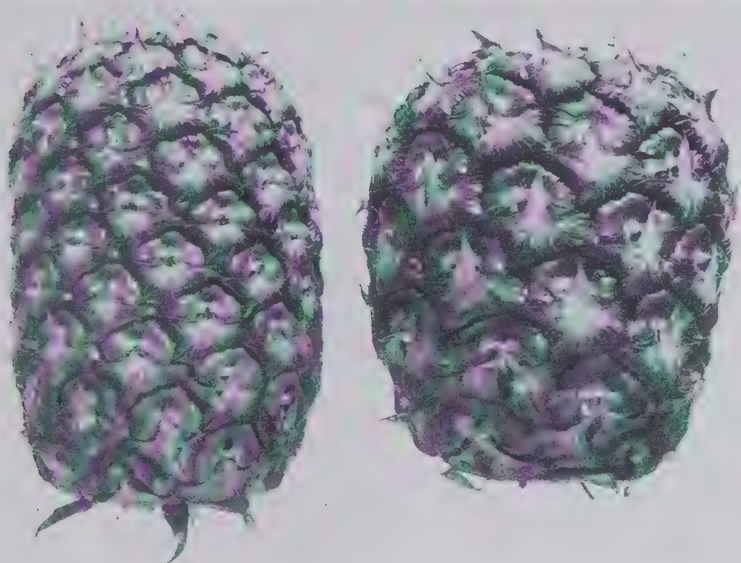

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PLATE 1. COMMON PHILIPPINE PINEAPPLES.

1

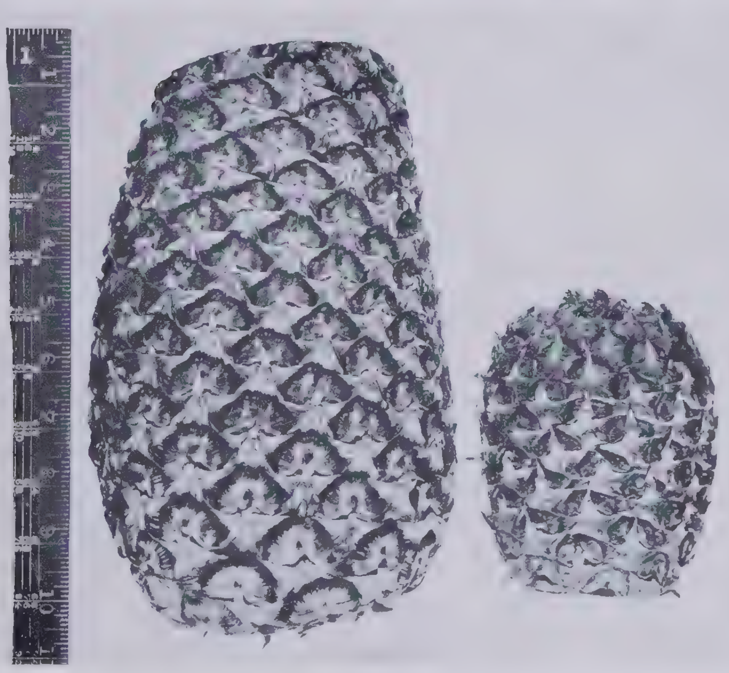

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PLATE 2. SMOOTH CAYENNE PINEAPPLES.

NOTES ON THE SEROLOGICAL RELATIONSHIP OF THE CHOLERALIKE VIBRIOS ISOLATED FROM HUMAN BEINGS AND FROM WATERS IN MANILA

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Following the cholera outbreak of 1925 in the City of Manila and neighboring provinces, an attempt was made by the Philippine Health Service to trace the probable source of infection in the Manila water resources. From September 23, 1925, to April 8, 1926, about 1,500 samples of water were submitted to the Bureau of Science and examined for the presence of vibrios. A very extensive survey was made by the special representative of the Philippine Health Service in Manila Bay, of the water samples taken from which vibriolike microörganisms were frequently found.

In connection with the study of choleralike organisms a special investigation was made of the possible relationship of choleralike vibrios isolated from water with those isolated from human beings, and that investigation forms the topic of this paper.

SOURCES AND HISTORY OF CULTURES OF VIBRIOS

I. Three choleralike vibrios isolated from human fæces:
- H–1. Isolated from the intestine of an autopsied case on October 7, 1925. Diagnosed as chronic interstitial nephritis.
- H–7. Isolated from the intestine of an autopsied case. Request No. 466–5B.
- H–14. Isolated from a food handler on May 15, 1925.

II. Five choleralike vibrios isolated from water:
- WT–9. From a dug well in Malabon. Isolated on October 13, 1925.
- WT–58. Isolated from sea water (Manila Bay); sample taken a half mile away from shore at a place called Bahay Pare, on October 23, 1925.
- WT–83. Isolated from sea water a half mile offshore, opposite Maytubig, on October 31, 1925 (Manila Bay).
- WT–110. Isolated from sea water opposite a place called Baclaran, on October 31, 1925 (Manila Bay).
- WT–137. Isolated from estero Reina Regente, a branch of Pasig River, on December 10, 1925.

III. True cholera vibrios, two strains:

Ch. 22. A strain used for the production of Bureau of Science anti-cholera serum.

Ch. 480. Isolated at autopsy from a clinically and anatomically typical case of cholera, on September 21, 1925.

METHODS OF STUDY

The three human choleralike vibrios were used for the production of specific sera and marked according to their respective cultures. These are referred to as human choleralike sera (H-1, H-7, H-14). Cross agglutination tests were made with the three sera (see Table 1).

A dilution of 1:50 of each of the three sera thus produced was used in agglutination tests performed with 250 strains of vibriolike organisms isolated from fish (12 strains), shrimp (1 strain), shell fish (4 strains), sewage (2 strains), drinking water (121 strains), and sea water (110 strains). Sixteen of the 250 strains were found agglutinable; eleven by the serum H-1, five by the serum H-14, and none by the serum H-7. Higher dilutions (up to 1:1600) were prepared of the sera H-1 and H-14. These were tested with the sixteen previously employed strains of vibrios. The interesting result was that only four strains were agglutinated by serum H-1 and one strain by serum H-14, giving complete agglutination in both sera in the dilution 1:1600.

Agglutination tests were made using an emulsion of about two thousand millions of the organisms per cubic centimeter so that the addition of an equal volume of diluted serum would result in a transparency of about one thousand millions per cubic centimeter. The total volume in case of both the agglutination and absorption tests was 2 cubic centimeters. In the absorption tests a 1:25 dilution of the serum was prepared and absorbed by the organism concerned, and incubated at 37° C. for about three hours. After that time all tubes showing marked agglutination were centrifuged, and the clear supernatant fluid was again similarly treated with the respective vibrios. Incubation overnight followed. When the upper portion of the liquid remained turbid or slightly cloudy the absorption was considered as completed. Then all tubes were centrifuged at a high speed to throw down the bacteria, and the clear supernatant fluids were decanted, properly diluted, and used for agglutination tests. Dilutions were made with 0.9 per cent sodium chloride and 24-hour-old cultures on alkaline agar (—1 per cent phenolphthalein) were used.

STUDY OF AGGLUTINATION AND ABSORPTION TESTS OF THE CULTURES WITH THEIR CORRESPONDING SERA

The agglutinability of the cultures of human and water choleralike vibrios and the true cholera vibrios was tested against the following sera: Bureau of Science anticholera serum, H–1, H–14, WT–58, WT–83, WT–110, and WT–137. Tables 2 and 3 show clearly that in high dilution these sera agglutinated only their respective homologous cultures and the ones that are similar to them with respect to agglutination.

In the absorption tests the following procedure was followed:

First, the sera used for agglutination tests (B. Sc. H–1, H–14, WT–58, WT–83, WT–110, and WT–137) were absorbed by their homologous cultures and tested against the human and the water choleralike vibrios and the true cholera vibrios. Table 4 clearly shows that the agglutinins of each serum were absorbed by the homologous cultures, leaving practically no agglutinins for itself nor for the others which were previously agglutinated.

Second, serum H–1 was absorbed by its homologous culture and tested against all water choleralike vibrios (see Table 5, I). Again, each serum prepared from water vibrios was separately absorbed by the other water choleralike cultures, and tested with the same cultures used for absorption (see Table 6, I, II, III, and IV), and again each water choleralike serum was absorbed by the human choleralike vibrio H–1, and tested afterward with culture H–1 (see Table 7). Lastly, the human choleralike serum (H–1) was absorbed by each of the choleralike vibrios from waters (see Table 8) and tested with the same water choleralike cultures.

Third, human choleralike serum H–1 and Bureau of Science anticholera serum were each absorbed separately by one strain of water choleralike vibrio (WT–9), by three strains of human choleralike vibrios (H–1, H–7, and H–14), and by two strains of true cholera vibrios (Ch. 22 and Ch. 480). The sera thus absorbed were then tested with the cultures used for absorptions and controlled by homologous cultures (H–1 and Ch. 22). (See Table 9.)

Fourth, serum H–14 was absorbed by its homologous culture and was then tested against the water choleralike vibrio (WT–9), which was previously found to be agglutinated by serum H–14 (see Table 5, II). Culture H–14 absorbed the agglutinins of its homologous serum H–14 leaving no agglutinins for itself and for culture WT–9. When culture WT–9 was used for the

absorption of serum H–14 it gave the same result as did its own homologous culture.

FINDINGS

Sera were prepared with the human choleralike vibrios (H–1, H–7, and H–14). In carrying out the cross-agglutination with these three human choleralike vibrios, it was found that they were serologically different from each other (see Tables 1, 2, and 3). A dilution of 1:50 was prepared of each of the three human choleralike sera (H–1, H–7, and H–14). Only sixteen of the 250 strains isolated from waters of different sources were agglutinated in this dilution. These sixteen strains were subjected to agglutination test using higher dilutions (1:1600) of the same sera. Of these sixteen strains four (WT–58, WT–83, WT–110, and WT–137) were agglutinated by the serum H–1, and one (WT–9) by the serum H–14. None was agglutinated by the serum H–7 in this high dilution. These five strains that were agglutinated to a higher dilution than 1:50 were vibrios isolated from waters and were the ones selected as the material for study.

The absorption test showed that the human choleralike vibrios absorbed their own agglutinins and those for water choleralike vibrios that were found previously agglutinable by their respective sera (see Tables 4 and 5, I and II). Each water choleralike vibrio absorbed the agglutinins for itself and for the other water choleralike vibrios of the same serological group (see Table 6). Human choleralike vibrios absorbed the agglutinins for the water choleralike vibrios completely. As Tables 7 and 8 show, they gave reciprocal absorption reaction. Human choleralike vibrios and water choleralike vibrios did not absorb the agglutinins of the anticholera serum. The agglutinins of the human choleralike serum (H–1) were not absorbed by the true cholera vibrios (Ch. 22 and Ch. 480). Nor were they absorbed by either the water choleralike vibrio (WT–9) or by the human choleralike vibrios (H–7 and H–14) that belonged in a different serological group (see Table 9).

DISCUSSION

From the standpoint of the history of the choleralike vibrios isolated from the water, it is interesting to note the wide distribution of this choleralike organism, the places from which

the samples were taken being widely separated. Their serological affiliation with the choleralike vibrios isolated from human stools is evidently shown by the result of the serological study of the cultures herein employed.

By agglutination tests, Greig(1) found it possible to classify into six groups most of the vibrios isolated from the water, but some remained ungrouped. He endeavored to correlate the choleralike organisms isolated from the water with high titer agglutinating sera prepared with choleralike vibrios isolated from stools of cholera cases in Calcutta, but none reacted with the sera prepared with the stool vibrios. He then studied 39 strains of choleralike vibrios isolated from water. It should be noted that our samples of water were collected at the end of the 1925 cholera outbreak. In connection with this, it is worth while to quote the statement of Schöbl(2) in regard to the study of viability of the cholera vibrios by inoculating fresh and sea water with cholera stool. He says:

> The theoretical possibility in the Philippine Islands of introducing Asiatic cholera from port to port by means of water carried on ships and of maintaining a source of infection in waters polluted with human excreta finds experimental corroboration.

He demonstrated that cholera vibrios may survive in sterile sea water inoculated with cholera fæces for as long as one hundred six days.

The serological qualities of the choleralike vibrios as distinct from true cholera vibrios define their present status as nonagglutinable and agglutinable cholera vibrios when high-titer cholera serum is used. The cultural and sugar reactions of the eight cultures of choleralike vibrios that were studied and are presented in this paper were the same as those of true cholera vibrios. The water and human choleralike vibrios were strongly hæmolytic. The theoretical consideration of the possible alteration of the receptors of the bacterial cell remains as yet to be investigated.

SUMMARY AND CONCLUSIONS

Five choleralike vibrios isolated from water were found serologically and otherwise identical with choleralike vibrios isolated from human beings. Both the human and the water choleralike vibrios were strongly hæmolytic. Their sugar reactions were identical with those of true cholera vibrios.

In many instances choleralike vibrios were frequently found in stools of healthy persons in the beginning or toward the end of outbreaks of cholera. Furthermore, nonagglutinable choleralike vibrios may be found simultaneously or alternatively with agglutinable cholera vibrios in cholera patients and convalescents. The finding of nonagglutinable choleralike vibrios in waters that are culturally and serologically identical with those found in human fæces may be significant from the epidemiological standpoint. In as much as these water choleralike vibrios were found in the sea water and in the water from a dug well, in sea food, and in certain drinking waters, the presence of these vibrios must be considered as a source of infestation by means of those so frequently encountered in the Philippines in healthy carriers. By analogy with the interpretation of the finding of *Bacillus coli* in drinking waters as an indicator of fæcal contamination the finding of the nonagglutinable choleralike vibrios, particularly those that are not only culturally but also serologically identical, can be safely used as an indicator of pollution with carrier fæces.

KEY TO TABLES

++++, complete agglutination.
+++, almost complete agglutination.
++, weak agglutination.
+, very weak agglutination.
±, trace (ocular).
—, negative.

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Thanks are due to Dr. Otto Schöbl, chief of the division, for his kind advice and valuable sugestions.

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TABLE 1.—*Showing the results of cross-agglutination tests of the three human choleralike-vibrio sera with their corresponding cultures.*

Culture, human cholera-like vibrio.	Human choleralike serum (H-1).								Human choleralike serum (H-7).			
	1:50	1:100	1:200	1:400	1:800	1:1600	1:3200	Control.	1:50	1:100	1:200	1:400
H-1	++++	++++	++++	++++	++++	++++	++++	—	—	—	—	—
H-7	—	—	—	—	—	—	—	—	++++	++++	++++	++++
H-14	—	—	—	—	—	—	—	—	—	—	—	—

Culture, human cholera-like vibrio.	Human choleralike serum (H-7).				Human choleralike serum (H-14),							
	1:800	1:1600	1:3200	Control.	1:50	1:100	1:200	1:400	1:800	1:1600	1:3200	Control.
H-1	—	—	—	—	—	—	—	—	—	—	—	—
H-7	++++	++++	++++	—	—	—	—	—	—	—	—	—
H-14	—	—	—	—	++++	++++	++++	++++	++++	++++	++++	—

TABLE 2.—*Showing the agglutination tests of human and water choleralike vibrios and true cholera vibrios by one cholera serum, two human choleralike sera, and four water choleralike sera.*

Culture employed.	Anticholera serum.		Serum H-1.		Serum H-14.		Serum WT-58.		Serum WT-83.		Serum WT-110.		Serum WT-137.	
	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.	Dilution 1 to—	Reading.
H-1	25	+	1600	++++	25–100	++ ±	1600	++++	1600	++++	1600	++++	1600	++++
H-7	25	—	25–50	++ +	25–100	++ ±	25	—	25	—	25	—	25	+
H-14	25–50	+ ±	25–200	++ ±	1600	++++	25–400	++++	25–200	++ +	25–200	++ +	25–400	+++ ±
WT-9	25	—	25–200	++ ±	1600	++++	25–50	+ ±	25	+	25	+	25	—
WT-58	25–50	++ ±	1600	++++	25	±	1600	++++	1600	++++	1600	++++	1600	++++
WT-83	25–100	+ ±	1600	++++	25	—	1600	++++	1600	++++	1600	++++	1600	++++
WT-110	25–50	+ +	1600	++++	25	-	1600	++++	1600	++++	1600	++++	1600	++++
WT-137	25	+	1600	++++	25	—	1600	++++	1600	++++	1600	++++	1600	++++
Chol. 22	1600	++++	25–200	+++ ±	25–200	++ +	25	±	25	+	25–50	+ ±	25	±
Chol. 480	1600	++++	25–200	++ ±	25–200	++ +	25	—	25	—	25	—	25	—

TABLE 3.—*Showing the results of cross-agglutination test of the ten cultures by the use of their corresponding sera.*

Choleralike and anticholera serum.	Human and water choleralike vibrios and true cholera vibrios.											
	WT-58	WT-83	WT-110	WT-137	H-1	H-7	H-14	WT-9	Ch-22	Ch-480	Titer.	Dilution employed.
WT-58	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
WT-83	++++	++++	++++	++++	++++	—	—	±	—	—	1600	1:200
WT-110	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
WT-137	++++	++++	++++	++++	++++	—	—	+	—	—	1600	1:200
H-1	++++	++++	++++	++++	++++	—	+	+	—	—	3200	1:200
H-7	—	—	—	—	—	++++	—	+	—	—	1600	1:200
H-14	+	—	—	—	—	—	++++	++++	—	—	3200	1:200
Ch-22	—	—	—	±	—	—	±	++	++++	++++	1600	1:200
Control	—	—	—	—	—	—	—	—	—	—	(a)	(a)

[a] Salt solution.

TABLE 4.—*Showing the results of absorption test of human and water choleralike sera and cholera serum by their homologous cultures.*

Serum—	Absorbed by culture—	H-1	H-7	H-14	WT-9	WT-58	WT-83	WT-110	WT-137	Ch-22	Ch-480	Dilution.	Titer sera.
Ch-22	Ch-22	—	—	—	—	—	—	—	—	±	—	1:200	1600
H-1	H-1	—	—	—	—	—	—	—	—	—	—	1:200	3200
H-14	H-14	—	—	±	—	—	—	—	—	—	—	1:200	3200
WT-58	WT-58	—	—	—	—	±	—	—	—	—	—	1:200	1600
WT-83	WT-83	—	—	—	—	—	—	—	—	—	—	1:200	1600
WT-110	WT-110	—	—	—	—	—	—	—	—	—	—	1:200	1600
WT-137	WT-137	—	—	—	—	—	—	—	—	—	—	1:200	1600

TABLE 5.—*Showing the results of absorption test of human choleralike sera (H–1 and H–14) by their homologous cultures and tested against choleralike vibrios from water.*

Culture.	1:50	1:100	1:200	1:400	1:800	Control.
I. Absorbed H–1 serum by culture H–1.						
WT–58	—	—	—	—	—	—
WT–83	—	—	—	—	—	—
WT–110	—	—	—	—	—	—
WT 137	—	—	—	—	—	—
H–1	+	—	—	—	—	—
II. H–14 serum absorbed by culture H–14.						
WT–9	—	—	—	—	—	—
H–14	±	—	—	—	—	—

TABLE 6.—*Showing the results of absorption test by making each water choleralike serum separately absorbed by others.*

Culture.	1:50	1:100	1:200	1:400	1:800	Control.
I. Serum WT–58 absorbed by—						
WT–83	—	—	—	—	—	—
WT–110	—	—	—	—	—	—
WT–137	—	—	—	—	—	—
II. Serum WT–83 absorbed by—						
WT–58	—	—	—	—	—	—
WT–110	—	—	—	—	—	—
WT–137	—	—	—	—	—	—
III. Serum WT–110 absorbed by—						
WT–58	—	—	—	—	—	—
WT–83	—	—	—	—	—	—
WT–137	—	—	—	—	—	—
IV. Serum WT–137 absorbed by—						
WT–58	—	—	—	—	—	—
WT–83	—	—	—	—	—	—
WT–110	—	—	—	—	—	—

TABLE 7.—*Showing the results of absorption test of water choleralike sera by human choleralike culture (H–1).*

Dilution.	1:50	1:100	1:200	1:400	1:800	Control.
Serum WT–58 absorbed by—						
Culture H–1	±	—	—	—	—	—
Serum WT–83 absorbed by—						
Culture H–1	—	—	—	—	—	—
Serum WT-110 absorbed by—						
Culture H–1	—	—	—	—	—	—
Serum WT–137 absorbed by—						
Culture H–1	—	—	—	—	—	—

TABLE 8.—*Showing the results of human choleralike serum (H–1) absorbed by the choleralike vibrios from water.*

Culture.	Absorbed serum H–1 diluted to 1 to—					
	50	100	200	400	800	Control.
WT–58	—	—	—	—	—	—
WT–83	—	—	—	—	—	—
WT–110	—	—	—	—	—	—
WT–137	—	—	—	—	—	—

TABLE 9.—*Showing results of absorption tests of human choleralike serum (M-1) and anticholera serum "Bureau of Science," by one strain of water choleralike vibrio (WT-9), three strains of human choleralike vibrios, and two strains of true cholera vibrios.*

Dilution employed.	H-1 serum absorbed by—										
	WT-9		H-7		H-14		Chol. 22		Chol. 480		H-1
	WT-9	H-1	H-7	H-1	H-14	H-1	Ch. 22	H-1	Ch. 480	H-1	H-1
1-25	±	+++	—	++++	±	+++	+	+++	+	+++	++
1-50	—	++++	—	++++	—	+++	±	++++	±	++++	+
1-100	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-200	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-400	—	++++	—	++++	—	++++	—	++++	—	++++	—
1-800	—	++++	—	++++	—	++++	—	++++	—	++++	—
Control	—	—	—	—	—	—	—	—	—	—	—

Dilution employed.	Anticholera serum "Bureau of Science" absorbed by—										
	H-1		H-7		H-14		WT-9		Chol. 480		Chol. 22
	H-1	Ch. 22	H-7	Ch. 22	H-14	Ch. 22	WT-9	Ch. 22	Ch. 480	Ch. 22	Chol. 22
1-25	±	+++	—	+++	—	+++	—	+++	—	—	++
1-50	—	++++	—	++++	—	+++	—	+++	—	—	+
1-100	—	++++	—	++++	—	++++	—	++++	—	—	±
1-200	—	++++	—	++++	—	++++	—	++++	—	—	—
1-400	—	++++	—	++++	—	++++	—	++++	—	—	—
1-800	—	++++	—	++++	—	++++	—	++++	—	—	—
Control	—	—	—	—	—	—	—	—	—	—	—

ENVIRONMENTAL FACTORS OF PHILIPPINE BEACHES WITH PARTICULAR REFERENCE TO THE BEACH AT PUERTO GALERA, MINDORO

By RAYMOND KIENHOLZ [1]

Of the University of Illinois, Urbana

FOUR FIGURES

Environmental factors, climatic, eadphic, physiographic, and biotic, all have a profound effect upon the distribution, form, and structure of the plants growing in any given area. The last two of these sets of factors, however, act primarily through the first two, and it is these that are given emphasis here. In any attempt to determine this effect upon plants it is first necessary to know what these factors are, and the intensity of each. This has been done in part for the plants of the beach, and in the following pages are recorded the results of observations and readings made during the months of April and May at Puerto Galera, Mindoro, as well as the findings of others working in various parts of the Islands.

The effect of these factors upon the vegetation, and particularly upon the structure of its principal transpiring organ, the leaf, has been fully discussed in another publication. (3)

Temperature.—The climate of the Philippine Islands is essentially a tropical one, except at high altitudes. The presence of great bodies of water, which are kept at an even but high temperature by ocean currents, (4, p. 10) makes the air temperature of the beach throughout the Islands particularly uniform. The seasonal as well as the daily fluctuations are very slight. This applies particularly to the temperature conditions on the beach at Puerto Galera. The nearest weather station at which meteorological readings have been taken for a long

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period and which is most nearly comparable in climatic features to Puerto Galera is Calapan, 32 kilometers to the south.(1) At this station the mean annual range, from the hottest month, May—28° C. (82.4° F.)—to the coldest month, February—25.6° C. (78.1° F.)—is only 2.4° C. (4.3° F.). This uniformity is partly due to the sea breezes sweeping up and down the coast, for at Batangas, only 16 kilometers distant but in a deep, protected bay, the mean annual range is 3.2° C. (5.8° F.), while the temperature is uniformly higher. The average monthly and annual temperatures for Calapan based on ten years' observations are as shown in Table 1.

TABLE 1.—*Average temperatures at Calapan, Mindoro.*

Month.	Degrees C.	Degrees F.	Month.	Degrees C.	Degrees F.
January	25.7	78.3	July	27.5	81.5
February	25.6	78.1	August	27.6	81.7
March	26.8	80.2	September	27.2	81.0
April	27.7	81.9	October	27.2	81.0
May	28.0	82.4	November	26.9	80.4
June	27.9	82.2	December	26.2	79.2
Average annual				27.0	80.6
Mean annual range				2.4	4.3

Standard Weather Bureau type maximum and minimum thermometers, properly installed in the shade, at about 1 meter above the ground, on the beach at Puerto Galera, were read at 6 p. m. daily, and for a part of the period at 6 a. m. The average minimum temperature for the period recorded (March 27 to June 5) was 75.8° F., the average maximum (May 4 to June 5) was 88.6° F., while the air temperature at the 6 p. m. reading averaged 82.6° F. The air temperature readings from May 21 to May 31 at 6 a. m. averaged 76.7° F., while those taken at 6 p. m. during the same period averaged 80° F. Copeland(2) summarizes the temperature on the beach at San Ramon, Zamboanga Province, Mindanao, as shown in Table 2.

These averages indicate fairly cool nights and days that are only occasionally excessively hot.

Rainfall.—The rainfall of the Islands is an extremely variable one, reducible, however, to two main types and two intermediate types.(1) One main type consists of "two pronounced seasons, wet and dry;" the other main type consists of "no dry season, with a very pronounced maximum rain period in winter." Puerto Galera is in an area characterized

TABLE 2.—*Temperature on the beach at San Ramon, Zamboanga Province, Mindanao.*

Month.	Temperature at—					
	6 a. m.		12 noon.		4 p. m.	
	°C.	°F.	°C.	°F.	°C.	°F.
November	24.4	74.9	27.4	81.3	26.8	80.2
	7.30 a. m.		11.30 a. m.		4 p. m.	
December	25.7	78.2	28.0	82.4	27.7	81.9
January	25.3	77.5	28.3	82.9	27.4	81.3
February	23.1	73.5	28.1	82.58	28.1	82.58
March	24.9	74.8	29.0	84.2	28.4	83.1
April	26.5	79.7	29.9	85.8	29.5	85.1

by an intermediate type of rainfall; namely, "no very pronounced maximum rain period and no dry season." This is true of Calapan also and, as no year-long rainfall measurements were taken at the former place, the weather records for Calapan covering a ten-year period are here indicated (Table 3).

TABLE 3.—*Rainfall in Calapan, Mindoro, over a period of ten years.*

Month.	Milli-meters.	Inches.	Month.	Milli-meters.	Inches.
January	117.8	2.99	July	227.1	5.76
February	77.7	1.97	August	101.2	2.56
March	75.2	1.91	September	235.4	5.97
April	110.2	2.76	October	252.2	6.40
May	170.1	4.32	November	310.5	7.88
June	242.7	6.16	December	205.0	5.2
Annual				2,125.1	53.44

These figures indicate a fairly uniform supply of rainfall throughout the year, as contrasted with Batangas, in Luzon, where the average monthly rainfall for the four driest months, from January to April, is only 20.4 millimeters (0.52 inch). The months of February and March are considerably drier than are the other months of the year, and evidences of this drier period are visible even in the vegetation at Puerto Galera, affecting particularly the grasses and other herbaceous vegetation. When the rains begin in May and June, many plants begin to show increased vigor, new leaves being put out, and the whole taking on a greener, more flourishing appearance.

This is especially true of some of the ferns (*Drynaria*) and of the herbaceous vegetation growing among the rocks and in the scanty soil of the rocky beaches and rocky headlands where they are almost wholly dependent on the current rainfall for their water supply.

That this varying seasonal distribution of the rainfall in different parts of the Islands, even in closely contiguous areas, has an effect on the distribution of the vegetation cannot be doubted.(4, p. 11) This would apply much more to the interior of the Islands than to the beaches, particularly the sandy beaches, and the mangrove and nipa areas. I do not believe, however, that it would materially effect the distribution of the large perennials such as trees, woody vines, and shrubs growing on the beach which usually root deeply enough to secure a perpetual supply of water; nor would it affect the herbaceous species found on the beach or their form and structure, though it would probably limit their appearance on the beach to the seasons of higher rainfall. Thus, herbaceous species growing on the beach at Puerto Galera the year round would be limited to the wetter months of the year at Batangas with its "dry season." The effect of seasonal rainfall with its accompanying high humidity is shown by the behavior of epiphytes.(4, p. 14) Many epiphytes, particularly ferns and orchids, are found growing along the beach at Puerto Galera, where the uniform rainfall and constant high humidity make this distribution possible. These epiphytes are not found growing on the Batangas side of Verde Island Passage, except at a high altitude, because of the dry season that prevails there during January to April.

Relative humidity.—Relative humidity is high in most parts of the Philippines, even during the drier periods of the year. This is particularly true of the beaches, and may be attributed to the high evaporation from the seas surrounding the Islands, to the rich vegetation, and to the abundant yearly rainfall. The mean monthly and annual relative humidity for Manila may be cited as an example (Table 4).

The weather station at Manila is some distance removed from the beach itself. This fact makes the above-cited readings slightly lower than they would be if read directly on the beach.

This factor will vary with local conditions, such as prevailing winds, exposure to sun and wind, temperature, and vegetation, as well as the exact time and place at which the readings are taken. A limited number of readings made with the

TABLE 4.—*Mean relative humidity at Manila.*

Month.	Per cent.	Month.	Per cent.
January	78.7	July	85.2
February	73.8	August	85.3
March	70.8	September	86.2
April	69.3	October	85.0
May	75.1	November	82.9
June	80.3	December	82.4
Annual			79.6

Weather Bureau type sling psychrometer on the open beach at Puerto Galera gave an average relative humidity of 80 per cent, even in the early afternoon with a temparature of 82° F.

Copeland (2) gives data on relative humidity on the beach at San Ramon, Zamboanga, which may be summarized as shown in Table 5.

TABLE 5.—*Relative humidity on the beach at San Ramon, Zamboanga Province, Mindanao.*

Date.	6 a. m.	12 noon.	4 p. m.
	P. ct.	*P. ct.*	*P. ct.*
November 15 to 30	88.8	79.9	83.3
	7. 30 a. m.	11. 30 a. m.	4 p. m.
December	84.27	79.2	80.52
January	84.74	75.65	80.28

November marks the close of the rainy season at San Ramon; hence, the higher relative humidity. Puerto Galera would show a higher relative humidity on the beach than would either San Ramon or Manila, because of the absence of a pronounced dry season, which San Ramon has for a short period and which Manila has for a longer period.

Evaporation.—The amount of evaporation at Puerto Galera, at five different stations (the sandy beach, the rocky headland, and three places in the mangrove swamp), was measured by standardized Livingston white spherical atmometers. The period from March 30 to May 8 was practically without rain, and the recorded evaporation for that period is entirely correct. The later observations are somewhat inaccurate, due to the lack of rain-correcting valves; but, wherever possible, the atmometers were read immediately after a rain and, as most of the rain fell at night and in spells alternating with rainless days,

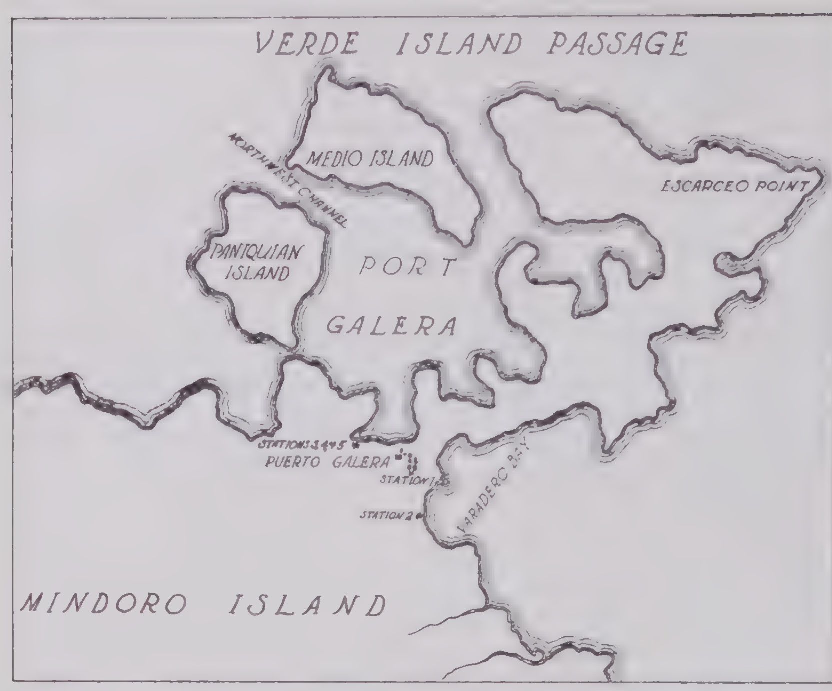

FIG. 1. Puerto Galera, Mindoro, and the surrounding region, showing the location of Stations 1 to 5.

the corrections made at 6 a. m. make the evaporation reading for the day accurate. In fig. 4 the periods of rain are indicated. Part of the low evaporation rate during the rainy periods is due of course to increased humidity and part of it to absorption by the bulb.

Burettes were used as water reservoirs in each case and these allowed daily readings of extreme accuracy. These burettes were plugged with cotton to prevent loss of water through evaporation and were covered with a glass phial to keep out rain and dust. The whole reservoir was protected also from direct sunlight. Distilled water was used in all cases.

Sandy beach (*Station 1*).—An atmometer was set up on the gently sloping sandy beach about 10 meters back from the water's edge and about 1.2 meters above its average level. The atmometer bulb was placed about 10 centimeters above the surface of the sand at the same level as the leaves of *Ipomoea pes-capræ* among which it was located. The burette was partly sunken in a pit dug in the sand. A second atmometer, similarly placed but having a wide-mouthed bottle as a reservoir, read sub-

stantially the same as the first atmometer, and the greater accuracy of the burette readings caused the data from the burette only to be used in Table 6 and in figs. 2 and 4.

Rocky headland (*Station 2*).—An atmometer was also set up at the edge of a rocky headland not far from the beach described above. This headland was a small hill with a sloping landward side and a steep, almost vertical, rocky seaward side. The waves washed its base on the seaward side at high tide. The headland towered about 15 to 25 meters above the sea, and on its extreme top on the seaward edge the atmometer was placed, fully exposed to all the winds coming from the east and the north. A sparse cover of trees provided some shade in the afternoon, but the rest of the day the bulb was exposed to the sun. The vegetation near the atmometer was brown and parched from lack of soil moisture and from the severe environmental conditions prevailing.

Mangrove swamp (*Stations 3, 4, and 5*).—In a small patch of young mangrove growing along the shore of the protected bay to the west of Puerto Galera, three atmometers were set up. This mangrove swamp consisted chiefly of *Rhizophora mucronata* and *R. candelaria* and covered several acres where a low flat valley bordered the bay. The trees were not large or tall but were in a thrifty condition, and showed evidence of encroaching on the mud flats formed by alluvial deposits brought down from the surrounding hills. The trees averaged 7.5 meters high and formed a dense canopy of foliage. The top of one of these trees was cut off and both an anemometer and a white spherical atmometer were placed so they were at the general level of the foliage of the canopy (Station 3).

A second atmometer was placed at the extreme outer edge of the mangrove and at all times except during extreme low tide the water covered the mud in which the mangrove grew and caused a reflection of light on the bulb from below. A very characteristic feature of the young advancing mangrove vegetation is the very sharp, clean-cut line above which a mass of foliage is displayed and below which no leaves are borne. This line is very noticeable, particularly at a distance, the lowermost foliage being always at a certain distance above the average level of the water, as if all the foliage below a certain line had been clipped off. At the level of this line the bulb of the second atmometer was placed to determine the possible added effect of reflection of light from the water below. The

bulb was exposed to the sun during part of the afternoon (Station 4).

The third atmometer was placed within the mangrove swamp, under the canopy at the level of the greatest mass of aërial brace roots, about 1 meter above the mud surface (Station 5).

TABLE 6.—*Daily evaporation on the sandy beach, rocky headland, and mangrove swamp, averaged by weeks.*

[Evaporation in cubic centimeters]

Week.	Sandy beach, Station 1.	Rocky headland, Station 2.	Mangrove swamp.		
			Station 3.	Station 4.	Station 5.
April 8–14	31.0		26.3	19.2	17.2
April 15–21	30.9	52.9	24.2	18.5	17.6
April 22–28	33.7	52.9	25.4	20.0	18.0
April 29–May 5	33.8	49.1	26.9	19.9	17.9
May 6–12	26.2	48.4	22.6	15.5	14.7
May 13–19	24.9	47.2	21.8	17.5	16.0
May 20–26	10.3	18.4	9.4	4.7	6.0
May 27–June 2	5.0	10.8			
Average	24.5	39.9	22.4	16.5	15.3

Table 6 indicates the average evaporation per twenty-four hours by weekly periods for the five stations. This is shown graphically in fig. 2. The evaporation for the rocky headland is consistently higher than that for any of the other stations. The rapid decline in the evaporation rates of all of the stations is due in part to an abundance of rain and to lessened wind movement from May 13 to June 2. This decline is especially evident in the case of the atmometer on the rocky headland. The rate of evaporation on the rocky headland was very high, averaging 52.9 cubic centimeters per twenty-four hours for the two weeks that were practically rainless. On some days when the wind was strong and the temperature high this rose to 72 cubic centimeters, a very high figure. The evaporation on the open sandy beach, not far from the rocky headland station, was second in amount, while the atmometers located at the top of the mangrove trees (Station 3), at the outer edge of the mangrove swamps (Station 4), and underneath the mangrove trees (Station 5) evaporated a decreasing amount in the order named. For the week April 22 to 28, when no rain whatever fell and the readings are entirely accurate, the ratio for the different stations was as follows: Rocky headland, 100; sandy beach, 64; at top of mangrove, 48; at edge of mangrove, 38;

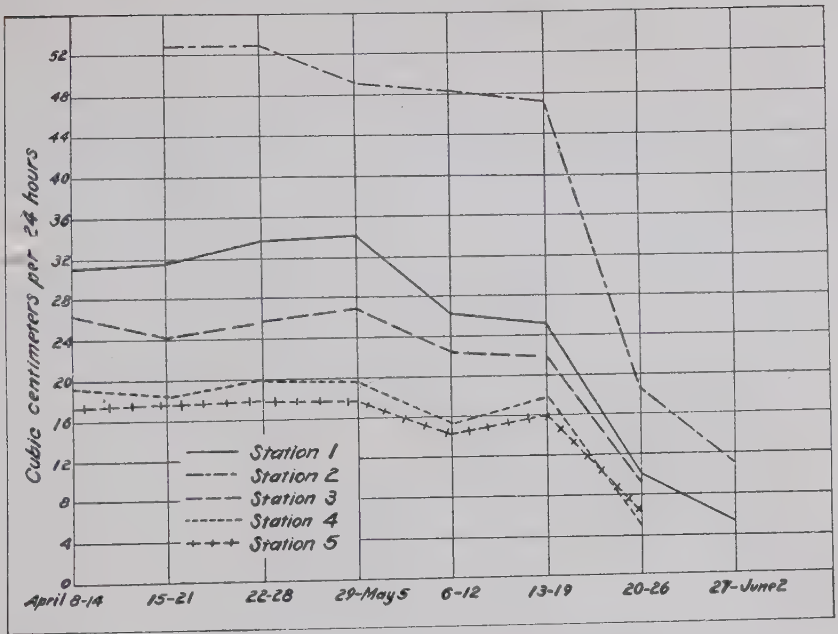

FIG. 2. Daily evaporation averaged by weeks for the sandy beach (Station 1), the rocky headland (Station 2), at the top of the mangrove trees (Sation 3), at the edge of the mangrove (Station 4), and underneath the mangrove trees (Station 5).

under the mangrove, 34. The ratio for the entire period, April 8 to June 2, was: 100, 61, 56, 41, 38.

Figures 3 and 4 show the very close correlation that exists between the amount of wind per twenty-four hours as measured on the beach and the amount of evaporation of the rocky headland and the sandy beach, respectively. The correlation is closer for the rocky headland than for the beach, as wind had a relatively greater influence on the headland than on the beach. If the data for the day (twelve hours) and the night (twelve hours) are compared separately a much closer correlation is found to exist between the night wind and the night evaporation. During the day sunlight enters to destroy the correlation. If data on sunshine were available they would explain some of the lack of correlation between wind and evaporation shown in figs. 3 and 4, just as the data for the rainy periods of April 12, April 19, and May 8 to 10 explain the lack of correlation in fig. 4.

This high evaporation rate in spite of the fairly high humidity gives a hint as to the reason for certain structural adaptations of the leaf for conserving its water supply.

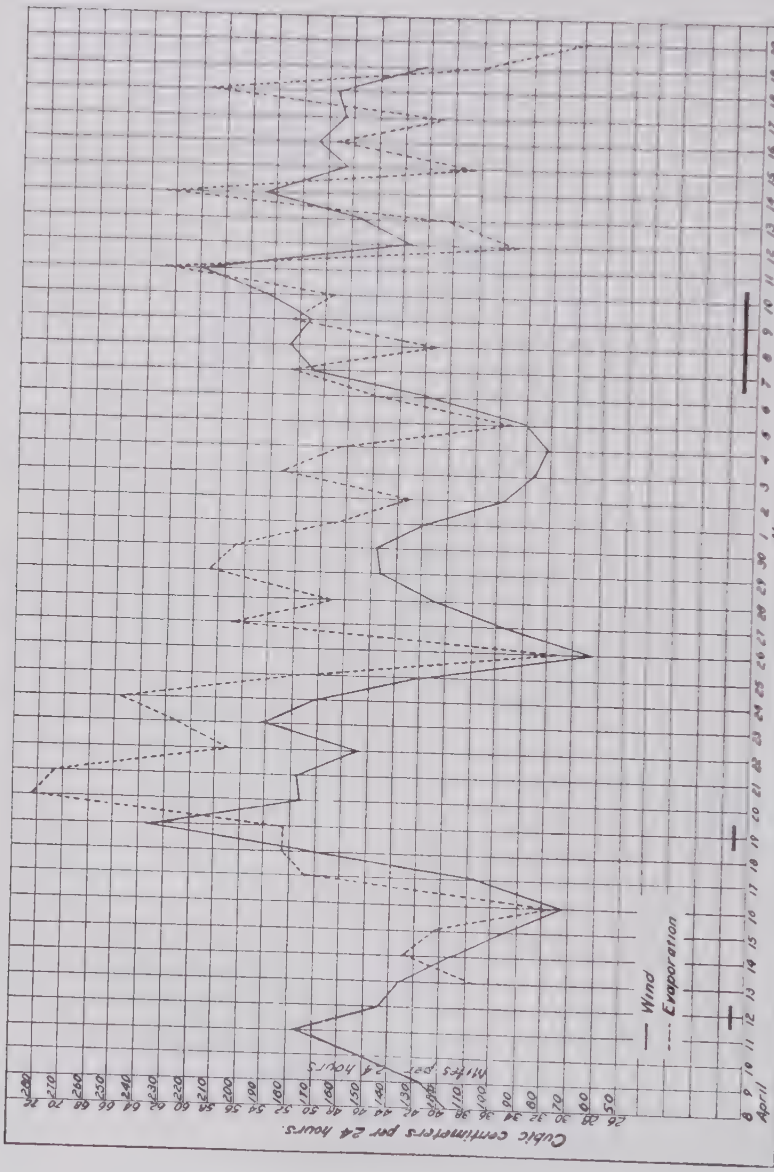

FIG. 3. Daily evaporation on the rocky headland and wind movement recorded on the beach. Rain indicated by black bars at base of graph.

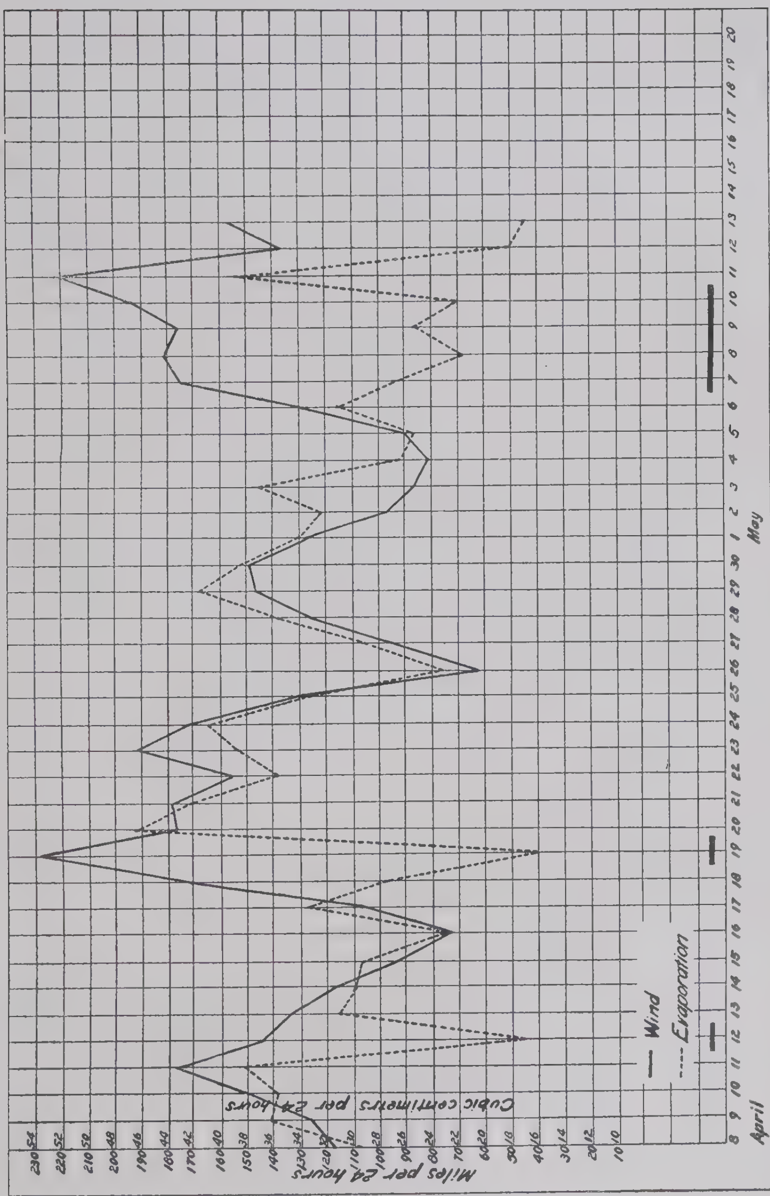

FIG. 4. Daily evaporation on the beach and wind movement recorded on the beach. Rain indicated by black bars at base of graph-

Wind.—Anemometers of the Freas type were set up on the sandy beach about 30 centimeters above the surface of the soil, and at Station 3 at the level of the tops of the mangrove trees. The wind was fairly strong and constant except during the later period of the readings when the rains were abundant. The average wind velocity in miles per twenty-four hours for the entire period of observation (March 25 to June 5) was 91.0 miles, while that for the period April 10 to April 22 was 146.8. The average daily wind movement averaged by weeks follows:

March 25 to 31, 158.2 miles; April 1 to 7, 96.3; April 8 to 14, 138.6; April 15 to 21, 146.9; April 22 to 28, 132.9; April 29 to May 5, 112.1; May 6 to 12, 173.3; May 13 to 19, 163.7; May 20 to 26, 28.5; May 27 to June 2, 29.5. The decided falling off in the evaporation rate, as shown in fig. 2, coincides with the greatly lessened wind movement of May 20 to June 2 and accounts in part for the falling off, the greatest decrease occurring where the wind was most effective in increasing the evaporation rate; namely, the rocky headland.

The wind movement at the top of the mangrove trees was very much less than that on the beach because of the protected position of the mangrove swamp. For the period May 14 to 29 the average daily wind movement on the beach was 72.8 miles as compared to 24.9 miles in the mangrove.

Sunshine.—No data are available on the amount of sunshine at Puerto Galera, but the data for Manila indicate an average annual cloudiness of 6.9 which reaches its minimum in April, with a figure of 4.6.

Soil.—The sandy soil of the beach allows water to drain away rapidly and, even when saturated, it holds but 20 to 22 per cent of water. It likewise contains very little humus. Whitford(5) gives the figure of 0.22 per cent of humus for sand near the water's edge. The sandy beach contains little salt, sometimes less than some cultivated soils. Whitford states that the sand of the Lamao beach, Bataan Province, Luzon, just above high-tide limits contained 0.25 per cent of sodium chloride and the amount was much less farther back on the beach. The water level on the sandy beach is often within a meter or two of the surface and deep-rooting plants thrive even through the dry season. This is not true of the rocky headland where the effects of the dry season are often marked.

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ILLUSTRATIONS

TEXT FIGURES

THE PHILIPPINE GARS OR NEEDLEFISHES

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FOUR PLATES

BELONIDÆ

GARFISH; NEEDLEFISH; BILLFISH; HOUNDFISH

Vernacular names.—Bicol, *baló, dugsó;* Ilocano, *siriu;* Pangasinan, *pingka;* Tagalog, *batalay;* Tagbanua, *tambalauang;* Tao Sug and Samal, *selo, tambuauang;* Visayan, *balo, dugso, gong-gong, tambilauan;* Spanish, *agujon, aguja de casta, peixe agulha, sierrita.*

A small family of very elongate and slender fishes, with laterally compressed or cylindrical bodies, covered with small to minute cycloid scales. The premaxillaries and mandibles are greatly prolonged to form a slender beak, both jaws filled with bands of small teeth in which are set numerous exceedingly sharp canines; teeth may be present or absent on tongue and vomer; the maxillary is more or less concealed by the large preorbital when the mouth is closed. The dorsal and anal are both very far back, the origin of the dorsal above or behind that of the anal, both fins rather long, without detached finlets; the pectorals are rather high, usually of medium size; the caudal may be forked, emarginate, truncate, or rounded; the ventrals are near the middle of the combined length of the trunk and head exclusive of the beak.

The lateral line is very low down, sometimes forming a low keel on the caudal peduncle; the gill openings are wide, the gill membranes not united with the isthmus; gill rakers present in one genus, absent or vestigial in the rest; the third pair of upper pharyngeals moderately enlarged, separate; second and fourth pairs present or absent; lower pharyngeals united into one plate; pharyngeal teeth usually villiform or granular; intestinal tract simple, without pyloric appendages; air bladder large; vertebræ with zygapophyses.

Fishes of tropical and temperate seas, some attaining a length of 1.66 meters, a few species entering fresh water. All the

species are more or less green during life, with silvery sides or a silvery longitudinal band, and often with a blue or blackish blue stripe from the shoulder to the caudal fin. The green color extends inward, so that the flesh and bones are green too. The flesh turns white in cooking and is excellent eating. The larger species are important food fishes where sufficiently abundant.

Gars swim at or near the surface offshore, in tidal currents, or in the open sea. In spite of their enormous jaws and terrible armament of needlelike teeth, gars can prey only on comparatively small fishes, since the gullet is too narrow to permit swallowing fish of any size. Silversides (Atherinidæ), anchovies (Engraulidæ), sardines (Clupeidæ), young caesios, and other small slender fishes seem to comprise the bulk of their food, at least around the reefs of the Sulu and Celebes Seas. If a half stick of dynamite is fired near a wharf in the Sulu Archipelago large numbers of silversides are always killed or stunned. At once several large gars will appear like magic from the stream, where their green backs harmonize perfectly with the color of the water, and in an incredibly short time they will snap up all the floating silversides and other small disabled fishes.

Gars swim with an undulating motion of the body and are exceedingly active. When startled they move with astonishing speed and may leap from the water several times or may skip over the surface in gigantic leaps like a ricochetting flat stone, or may rise out of the water until only the tail or posterior part of the body is left in it, just as a modern speed boat travels, shooting forward with incredible swiftness and all but flying. It sometimes happens on such occasions that a whizzing gar strikes a person with its hard bill which penetrates like an arrow, inflicting dangerous wounds, horribly lacerating the abdomen, or causing death. A snapping gar may also inflict very severe wounds with its large needlelike teeth.

Unless otherwise specified, the lengths given in this paper do not include the caudal fin.

Key to the Philippine genera of Belonidæ.

a^1. Premaxillaries swollen at base, jaws arched and not closing posteriorly; body bandlike, its height twice the breadth or more............*Ablennes.*

a^2. Premaxillaries not swollen at the base; jaws arched and not meeting posteriorly; body scarcely or moderately compressed, height less than twice the breadth.. *Tylosurus.*

Genus ABLENNES Jordan and Fordice

Athlennes JORDAN and FORDICE, Proc. U. S. Nat. Mus. 9 (1886) (1887) 342; error for *Ablennes;* correct form approved by International Commission of Zoölogical Nomenclature.

The very elongate body greatly compressed laterally, almost ribbon-shaped in some specimens; premaxillaries and mandibles extended into a very long slender beak; premaxillaries slightly constricted near their base and strengthened by a conical swelling of the bone, with the point directed forward; upper jaw strongly arched upward at its base so that the mouth cannot be closed; each jaw with a band of conical pointed teeth, sprinkled with larger slender canines; no teeth on vomer, origin of anal in advance of that of dorsal, all the dorsal and anal rays connected by a membrane; caudal forked; scales minute, adherent; lateral line very low down on body, not forming a distinct keel on caudal peduncle; gill openings wide; no gill rakers; lower pharyngeal long and narrow; second, third, and fourth pairs of upper pharyngeals with teeth.

Only one species known, of very wide distribution, in the Indian, Pacific, and Atlantic Oceans.

ABLENNES HIANS (Cuvier and Valenciennes). Plate 1, fig. 1.

Belone crocodila BLEEKER, Nat. Geneesk. Arch. Ned. Ind. 2 (3) (1845) 512; not of Lesueur.

Belone hians CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 321, pl. 548; GÜNTHER, Cat. Fishes 6 (1866) 248; Fische der Südsee 3 (1910) 353.

Athlennes hians JORDAN and FORDICE, Proc. U. S. Nat. Mus. 9 (1886) (1887) 342; JORDAN and EVERMANN, Fishes N. and M. Am., part 1 (1896) 718; JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1904) 433; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23^1 (1903) (1905) 125, fig. 40; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 131, fig. 49.

Ablennes hians JORDAN and JORDAN, Memoirs Carnegie Mus. 10 (1922) 18.

Belone melanostigma CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 334; GÜNTHER, Cat. Fishes 6 (1866) 241; KLUNZINGER, Synopsis Fische des Rothen Meeres (1871); DAY, Fishes of India (1878) 509.

Tylosurus melanostigma JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1902) 329.

Belone gracilis SCHLEGEL, Fauna Japonica, Poissons (1846) 246; not of Lowe; BLEEKER, Verh. Bat. Gen. 26 (1854–1857) Niew. nal. Japan, 116.

Belone schismatorhynchus BLEEKER, Nat. Tijds. Ned. Ind. 1 (1850) 95; KNER, Fische Novara Exp. (1865) 322; GÜNTHER, Cat. Fishes 6 (1866) 239; MEYER, Ann. Soc. España Hist. Nat. 14 (1885) 38.

Mastacembelus schismatorhynchus BLEEKER, Atlas Ichth. 6 (1866–(1867) 49, pl. 258, fig. 2.
Tylosurus schismatorhynchus JORDAN and STARKS, Proc. U. S. Nat. Mus. 26 (1903) 528.
Tylosurus caeruleofasciatus STEAD, New Fishes New South Wales, No. 1 (1908) 3.
Athlennes caeruleofasciatus OGILBY, Mem. Queensland Mus. 5 (1916) 130; MCCULLOCH, Check List Fishes New South Wales, part 2 (1919) 36.

Dorsal II–21 to 23; anal II–22 to 24; pectoral 1–13; lateral line about 410.

Body very strongly compressed, often bandlike, breadth 2 to 2.3 times in depth, which is 11.5 to 13.25 times in length in my specimens; the flattened sides of head strongly appressed below so that it is triangulate in section, 3.4 to 3.87 times in length; the very elongate and slender snout 1.37 to 1.47 times in head; the large eye very high up, 10.66 to 11.4 times in head, 7.3 to 8.1 times in snout, 1.15 to 1.3 times in interorbital space, and 2.25 to 2.65 times in postorbital part of head; mandible very broad posteriorly, its depth below pupil almost equal to diameter of eye; on top of posterior part of head is a broad, smooth, shallow depression, much narrower and triangulate anteriorly, with a median ridge above eye, the anterior half scaled; the supraorbital region strongly striated; a small median groove on beak, extending to its tip; the small numerous canines directed backward in upper jaw, and in large specimens the posterior canines of lower jaw also; tongue smooth; maxillary entirely covered by preorbital when the mouth is closed, or its margin may be barely visible; opercles naked, preopercles scaled; the large falcate elongate pectorals much longer than the postorbital region of head, 2.25 to 3.5 times in head; the lower lobe of the strongly forked caudal is the longer, and always exceeds pectoral; depth of caudal peduncle a third to a half more than its breadth; anterior part of caudal and anal elongate and strongly falcate, origin of dorsal opposite third to fifth divided anal ray, separated by 28 to 32 scales from lateral line; middle dorsal rays shorter than anterior or posterior ones, the last sometimes extending to caudal base; middle and posterior anal rays subequal in length; origin of ventrals midway between caudal base and anterior part of eye; lateral line does not form a keel on caudal peduncle.

Color of fresh specimens greenish above, the sides brilliant silvery whitish to pearly white; three to six broad vertical black-

ish spots or bands on posterior part of body behind origin of anal; dorsal blackish, the other fins all with blackish tips, pectorals and anal yellowish.

In alcohol the dorsal region is brown, distinct from the silvery white or more or less silvery yellowish sides; all the fins more or less blackish; the black spots or bands on posterior region tend to disappear in alcohol.

Here described from four specimens from Manila Bay, 480 to 875 millimeters in length, the largest one 975 millimeters long with the caudal fin. During November this fish is common in the Manila markets, and is often seen during the cooler months. The only previous Philippine record is that by Meyer, who collected it from Manila Bay and at Cebu.

This species, which reaches a length of more than a meter, occurs from the Red Sea to Japan, the Hawaiian Islands, and across the Pacific to Acapulco on the west coast of Mexico. It also occurs in the Atlantic, from North Carolina to Brazil.

Genus TYLOSURUS Cocco

Tylosurus Cocco, Giorn. Sci. Lett. Sicilia 42 (1833) 18.

Body very elongate and slender, cylindrical or laterally compressed, the laterally flattened head with a very long toothed beak, formed from the greatly extended premaxillaries and dentary; maxillaries united to premaxillaries; each jaw has a band of small sharp teeth, interspersed with much larger, widely spaced, very sharp conical teeth or canines; no vomerine teeth; origin of dorsal opposite or behind that of anal, both fins very far back and rather long, without finlets, all the rays connected by a membrane; caudal fin forked, truncate, or rounded; ventrals small, inserted behind middle of body; scales small to very small; lateral line very low, usually forming a fold along side of belly and sometimes forming an elevated keel on caudal peduncle; gill openings wide; no gill rakers; air bladder large; the lower pharyngeals unite in a long narrow flat plate, covered with small pointed teeth; upper pharyngeals distinct, second and third pairs each with unequal pointed teeth; fourth pair usually distinct, with similar teeth.

Greedy carnivorous fishes of tropical and temperate seas, of moderate to large size, esteemed as food. In early life the jaws are not prolonged and until maturity is nearly reached the lower jaw is much in advance of the upper; in *T. philippinus* Herre, the lower jaw extends beyond the upper in the adult stage.

The fishes of this genus usually swim at or near the surface, singly or in small groups, less often in schools of greater numbers, up to several hundred. When a school of Atherinidæ, young caesios, or other small fishes is broken up by a blast of dynamite, several large gars will immediately appear where none was visible before, and snap up the dead and dying fishes with great rapidity.

The larger species are much feared by fishermen, as when frightened they may skip along the surface of the water at terrific speed, hurtling through the air in great leaps and inflicting frightful injuries upon or even killing anyone unlucky enough to be in the way. They also damage small nets, through which they easily tear their way.

Key to the Philippine species of Tylosurus.

a^1. Caudal truncate or rounded; lateral line not forming keel on caudal peduncle.
- b^1. Dorsal I-12 or 14 to II-11 or 12; anal I-14 or 15 to II-13 to 16.
  - c^1. Lateral line 150–170; caudal with a basal circular black or deep blue spot .... *T. strongylurus.*
  - c^2. Lateral line 126–138; no dark spot on caudal base.... *T. macrolepis.*
- b^2. Dorsal I-17 or II-16 to 18; anal II-20 to 22.
  - d^1. Origin of dorsal above second divided anal ray........ *T. incisus.*
  - d^2. Origin of dorsal above seventh divided anal ray........ *T. leiurus.*

a^2. Caudal forked; lateral line forming a more or less evident keel on caudal peduncle.
- e^1. Canines of upper jaw inclined forward........ *T. giganteus.*
- e^2. All the canines perpendicular.
  - f^1. Mandible with a large thick spongy tip; lateral line 194; tongue mostly smooth........ *T. philippinus.*
  - f^2. No conspicuous spongy tip on mandible; lateral line more than 250.
    - g^1. Dorsal II-19 or 22; anal II-18 or 20; pectoral I-13; lateral line 270; tongue covered with large rounded hard tubercles. *T. crocodilus.*
    - g^2. Dorsal II-23 or 24; anal II-20 or 21; pectoral I-11 or 12; lateral line 300 to 350; tongue more or less covered with very small granular teeth........ *T. melanotus.*

TYLOSURUS STRONGYLURUS (van Hasselt). Plate 1, fig. 2.

Belone strongylura VAN HASSELT, Alg. Konst-en Letterbode, Deel 1 (1823) 130; WEBER, Fische Siboga Exp. (1913) 122.

Belone caudimacula CUVIER, Regne Anim., Disciples ed. 7 (1836) 234, footnote; CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 336; CANTOR, Journ. Asiat. Soc. Bengal **18** (1850) 1228; BLEEKER, Verh. Bat. Gen. **24** (1852) Snoekachtige Visschen, 12.

Mastacembelus caudimacula BLEEKER, Ned. Tijds. Dierk. **2** (1865) 176, 194.

Mastacembelus strongylurus BLEEKER, Ned. Tijds. Dierk. **3** (1866) 220; Atlas Ichthy. **6** (1866–1872) 45, pl. 257, fig. 3.

Belone caudimaculata GÜNTHER, Cat. Fishes 6 (1866) 245; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 38.

Belone strongylurus GÜNTHER, Cat. Fishes 6 (1866) 246; Day, Fishes of India (1878) 512, pl. 118, fig. 6.

Tylosurus caudimaculatus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 242; SEALE, Philip. Journ. Sci. § D 9 (1914) 60.

Tylosurus strongylurus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 121.

Dorsal I–12 or 14 to II–12; anal I–14 or 15 to II–14 to 16; pectoral 1–9 or 10; lateral line 150–170.

The elongate body slightly to moderately compressed, its breadth three-fourths the depth to nearly equal the depth; depth 14 to 17 times in length; head 2.5 to 2.9 times in length, its sides and top strongly flattened, the nearly circular eye 12 times in head, 2.4 to 4.1 times in postorbital part of head, 8.1 to 8.5 times in snout, and equal or nearly equal to the interorbital space; top of head with a well-developed median groove and a few striæ on region above eye; maxillary more or less concealed by preorbital, varying with age, largely hidden in the young; operculum and preopercle from eyes back covered with scales; canines small, erect or inclined slightly backward; tongue smooth; pectorals are usually shorter than postorbital part of head, but may be equal to or longer than it; base of ventrals midway between eye and base of caudal or a little nearer eye or caudal; anterior dorsal and anal rays highest, middle and posterior rays much shorter and of nearly uniform length; origin of dorsal over second to fourth anal ray; caudal peduncle slightly keeled, the lateral line not forming a keel; caudal rounded or lower rays longest, 9.2 to 9.7 times in length.

The color is a beautiful green to yellowish green above, thickly punctulated with minute brown specks, merging into silvery on sides and pearly white on abdomen; a deep blue longitudinal stripe on posterior half of sides, beneath is a wide silver band from head to tail; sides of head bright silver; dorsal, pectorals, and ventrals clear, dorsal and anal with a roseate margin, anal sometimes yellowish; caudal pearly to greenish or yellowish, with a deep blue circular spot on its base; upper surface of eye very dark bluish.

Color in alcohol brown, brownish, or yellowish above, paler to nearly white below, with a broad longitudinal silver band on side, very distinct on posterior third or half of body, where it is bordered above by a more or less evident dark or blue-black stripe; a large black or bluish black circular spot on caudal

base; fins colorless, or yellowish, or posterior half of caudal dusky.

Here described from the following specimens, ranging from 155 to 350 millimeters in length:

Bulacan, Bulacan Province, 1.	Cagayan, Misamis, Mindanao, 1.
Manila, 11.	Davao, Mindanao, 1.
Calabanga, Camarines Sur, 1.	Sandakan, Borneo, 2.
Tacloban, Leyte, 1.	Amoy, China, 1.

Specimens 250 millimeters or more in length are sexually mature; a female collected in February was ready to spawn. Dr. A. B. Meyer collected this species from Manila Bay and at Cebu; Jordan and Richardson had a specimen from Iloilo.

This species ranges from the coasts of Ceylon and Hindustan throughout the East Indies, north to the southern coast of China, and southeast to Thursday Island and North Australia, occurring in the sea and in estuaries. It is common in the Manila market during the winter months. It is said to reach a length of 450 millimeters, but I have seen none so large.

TYLOSURUS MACROLEPIS (Bleeker).

Belone macrolepis BLEEKER, Nat. Tijds. Ned. Ind. **12** (1856) 225.
Mastacembelus macrolepis BLEEKER, Ned. Tijds. Dierk. 3 (1866) 221; Atlas Ichthy. **6** (1866–1872) 45, pl. 258, fig. 1.
Belone macrolepis GÜNTHER, Cat. Fishes **6** (1866) 246; MEYER, Ann., Soc. España Hist. Nat. **14** (1885) 38.
Tylosurus macrolepis WEBER and BEAUFORT, Fishes Indo-Aust. Arch. **4** (1922) 122.

Dorsal II–11; anal II–13 or 14; pectoral 1–9 (1–10 according to other authors); scales in lateral line 126–138.

Body nearly cylindrical, depth and breadth equal, 14.8 times in length; head strongly compressed laterally and flattened above, about 2.25 times in length; eye about 12.6 times in head, about 8.4 times in snout, 1.1 to 1.2 times in interorbital, and 3 times or a little less than 3 times in postorbital part of head; top of head has a wide and very shallow scaly groove, broadest anteriorly; striæ on top of head not very well developed; maxillary two-thirds concealed by preorbital when mouth is closed; opercle and preopercle scaled; canines numerous, small, those of upper jaw more or less inclined backward; tongue smooth; pectorals pointed, narrow, a little more or less than length of postorbital region of head; ventral base midway between caudal base and middle or anterior margin of pupil; origin of dorsal over second or third anal ray, the anterior rays of both fins highest, the others much shorter and of nearly equal length, the last ending

at a considerable distance from caudal base; depth of caudal peduncle equals or is a third greater than its breadth; caudal more or less rounded to truncate, the lowermost rays longest, a little longer than postorbital region of head.

Color in alcohol brown, or grayish brown above, paler to yellowish below, sides of head silvery; a silvery longitudinal band on posterior half of body, much broader on last third, bordered above by a dark or blue-black line extending from shoulder to caudal; a large blackish patch on basal portion of pectoral, larger and plainer on inner side; a series of elongate dark spots on middle of dorsal and anal, forming a longitudinal band; a dark spot above each eye on top of head; hind margin of caudal dusky.

Here described from two specimens, one 268 millimeters long, and a larger one with the beak broken, but otherwise in fine condition. The smaller specimen is from Zamboanga, the other from Gingoog, Misamis Province, Mindanao. I also have three specimens from Zamboanga, one about 125 millimeters in length, another about 175, both with the beak broken; the third one, 160 millimeters long, is in perfect condition. In the Stanford University collection are two specimens collected by Alvin Seale at the mouth of Agusan River, Mindanao.

This rare species reaches a length of 420 millimeters. It is only known from a very few specimens, collected at Nias, Menado in Celebes, and the Sangir Islands.

TYLOSURUS INCISUS (Cuvier and Valenciennes).

Belone incisa CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 335; WEBER, Fische Siboga Exp. (1913) 123.

Tylosurus incisus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. **4** (1922) 125.

Belone leiuroides BLEEKER, Nat. Tijds. Ned. Ind. **1** (1851) 479; GÜNTHER, Cat. Fishes **6** (1866) 243.

Mastacembelus leiuroides BLEEKER, Atlas Ichthy. **6** (1866–1872) 50, pl. 255, fig. 1.

Tylosurus leiuroides JORDAN and SEALE, Bull. Bur. Fisheries **25** (1906) 206; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 58; SEALE and BEAN, Proc. U. S. Nat. Mus. **33** (1907) 240.

Belone liuroides, GÜNTHER, Fische der Sudsee **3** (1910) 352.

Strongylura leiuroides FOWLER, Proc. Acad. Nat. Sci. Phila. **71** (1919) 5.

Local name.—*Doal* at Iba, Zambales.

Dorsal II–17 or 18; anal II–20 or 21; pectoral 1–10 or 11; lateral line 168–190.

The elongate, rather thick body deepest and widest anteriorly in the region of the pectorals, body rather four-sided, breadth 75 to 85 per cent of the depth, which is 13 to 16 times in length; sides of head strongly flattened, its length 2.25 to 2.5 times in total, its upper surface more or less dished or nearly flat, with a wide shallow scaly median depression, not broadening anteriorly; the large eye placed high up, 10.7 to 11.3 times in head, 1.1 times in interorbital, 2.4 to 2.6 times in postorbital region, and 7.3 to 7.9 times in the long, slender, pointed snout, which is 1.45 to 1.5 times in head; top of head densely striated; beak also striated longitudinally, with a deep central longitudinal groove; diameter of eye much greater than depth of mandible below pupil; when the mouth is closed the preorbital covers all of the maxillary except the lower margin; scales on preopercle very large, those on opercle smaller and easily rubbed off; canines numerous, straight, very sharp, those of upper jaw stronger; tongue smooth; postorbital portion of head about 0.9 of pectoral length; origin of ventrals midway between caudal base and center or anterior portion of eye; middle and posterior dorsal and anal rays short, subequal in length, much shorter than anterior ones, which are long and boldly falcate; posterior dorsal and anal rays end some distance before caudal base; origin of dorsal above second divided anal ray; caudal moderately forked, about 9 times in length, longer than postorbital region of head; depth of caudal peduncle slightly exceeds its breadth.

Color in alcohol brown above, pale yellowish and silvery below, with a very distinct blue or blue-black stripe from shoulder to caudal, above an indistinct silvery band; a median black line from nape to origin of dorsal and another on each side of it; a curved blackish line on base of pectoral rays; preopercles and opercles silvery, and sprinkled with pale brown spots, which may disappear with age; central portion of caudal dusky.

Here described from the following specimens, 245 to 480 millimeters in length:

Polillo, 1.
Iba, Zambales, 1.
Estancia, Panay, 1.
Bantayan, 1.
Tandubas, Sulu Province, 1.
Bato Bato, Tawitawi, 2.
Sitankai, 2.

Evermann and Seale had a specimen from Bacon, Sorsogon, and Seale and Bean had four specimens from Zamboanga; Fowler had a specimen from the Philippines.

This species, which reaches a length of 600 millimeters, occurs from the Indian Ocean throughout the East Indies to New Gui-

nea, the Pelew and Admiralty Islands, and southeast in the Pacific to Samoa.

TYLOSURUS LEIURUS (Bleeker). Plate 2.

Belone leiurus BLEEKER, Nat. Tijds. Ned. Ind. 1 (1850) 94; KNER, Fische Novara Exp. (1865) 321; DAY, Fishes of India (1878) 511.

Mastacembelus leiurus BLEEKER, Atlas Ichthy. 6 (1866–1872) 46, pl. 257, fig. 2.

Tylosurus leiurus JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 329; JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 8; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 240; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 243; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 124.

Belone liurus GÜNTHER, Cat. Fishes 6 (1866) 250.

Strongylura leiura FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Mastacembelus anastomella BLEEKER, Ned. Tijds. Dierk. 3 (1866) 244; (not of Cuvier and Valenciennes).

Local name.—*Batalay* in Tagalog.

Dorsal II–16 to 18 or I–17; anal II–21 or 22; pectoral I–10 or 11; lateral line 200–220.

The depth of the elongate, laterally compressed body 16 to 20 times in length and 1.4 to 1.6 times its breadth; head contained 2.7 to 3.1 times in length, its sides and top flattened; eye 10 to 13 times in head, 2.7 to 3.1 times in postorbital part of head, 1 to 1.2 times in interorbital, 8.4 to 9 times in snout; the depth of the short caudal peduncle greater than its width; a broad shallow median scaly groove on top of head, much broader anteriorly, with a very low median longitudinal ridge, which disappears anteriorly; top of head but little striated; two-thirds or more of maxillary hidden by preorbital; postorbital region of head scaly; canines slender, inclined backward; tongue smooth; pectorals equal to or a little more or less than postorbital portion of head; origin of ventrals a little nearer base of caudal than to hind border of eye or sometimes midway; dorsal and anal both falcate, anterior rays much longer than the others, which are subequal in height; origin of dorsal much behind that of anal, above seventh anal ray; caudal fin subtruncate, inferior rays longest, 9.25 to 10 times in length.

Color in alcohol light brown above, pale yellowish brown on sides, with a broad silvery lateral band, bordered above by a dark line, from above origin of pectoral to base of caudal; a large black or dusky subterminal blotch on pectoral; posterior two-thirds of caudal dusky; dorsal and anal dusky to yellowish or colorless; ventrals yellowish or colorless.

Here described from the following specimens, 350 to 400 millimeters in length: Santa Maria, Ilocos Sur, 1; Manila, 2; Hoihow, Hainan, 1. It was listed by Jordan and Richardson from Aparri, from Cavite by Jordan and Seale, and from Zamboanga by Seale and Bean.

This species, which reaches a length of over half a meter, occurs from Ceylon and Hindustan eastward to the Aru Islands, and north to Formosa.

TYLOSURUS GIGANTEUS (Schlegel). Plate 4, fig. 1.

Belone gigantea SCHLEGEL, Fauna Japonica, Poissons (1842) (1846) 245; BLEEKER, Act. Soc. Sci. Indo-Neerl. **3** (1858) Japan, 21; GÜNTHER, Fische der Südsee **3** (1910) 350; WEBER, Fische Siboga Exp. (1913) 122.

Mastacembelus giganteus BLEEKER, Ned. Tijds. Dierk. **1** (1863) 236.

Tylosurus giganteus JORDAN and STARKS, Proc. U. S. Nat. Mus. **26** (1903) 529; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23** [1] (1903) (1905) 124, fig. 39; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 773; Bull. Bur. Fisheries 26 (1907) 8; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 58; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 242.

Belone annulata CUVIER and VALENCIENNES, Hist. Nat. Poiss. **18** (1846) 332, pl. 550; CANTOR, Journ. Asiat. Soc. Bengal **18** (1850) 1226; GÜNTHER, Cat. Fishes **6** (1866) 240; DAY, Fishes of India (1878) 510, pl. 120, fig. 1.

Mastacembelus annulatus BLEEKER, Ned. Tijds. Dierk. **3** (1866) 229; Atlas Ichthy. (1866–1872) 48, pl. 258, fig. 3.

Tylosurus annulatus WEBER and BEAUFORT, Fishes Indo-Aust. Arch. **4** (1922) 126; SEALE, Philip Journ. Sci. § D **5** (1910) 267.

Belone melanurus BLEEKER, Verh. Bat. Gen. **22** (1849) Bijdr. Ichth. Madura, 11.

Belone timucodes BLEEKER, Journ. Ind. Arch. **3** (1849) 67 and 68.

Belone cylindrica BLEEKER, Verh. Bat. Gen. **24** (1852) Snoekacht. Visschen. 13; KNER, Fische Novara Exp. (1865) 321.

Mastacembelus choram BLEEKER, Ned. Tijds. Dierk. **3** (1866) 277; not of Rüppell.

Local name.—Tagalog, *batalay.*

Dorsal II–20 to 22; anal II–18 to 20; pectoral 1–12 to 14; lateral line scales 350–380

Depth of the moderately compressed body 14.4 to 15.2 times in length, breadth 1.3 to 1.5 times in depth; head 3 to 3.25 times in length; eye 9.3 to 10 times in length, 5.9 to 6.4 times in snout, 2.3 to 2.6 times in postorbital portion of head, and 1.2 to 1.3 times in interorbital space; depth of mandible below eye equals half the longitudinal diameter of eye and is a little more than half the vertical eye diameter; top of head flat, with a wide shallow median groove, with a patch of very small scales at

forward end; sides of groove strongly furrowed and ridged; supraorbital region covered with very feeble striæ; maxillary hidden or only posterior portion of its lower margin visible when mouth is closed; preopercle covered with small scales, opercle naked or with a few small scales, anteriorly or on lower part; canines well developed, awl-shaped, inclined forward; tongue covered with granular teeth or middle of anterior portion naked; the broad pointed pectoral a trifle shorter than postorbital region of head; base of ventrals midway between caudal base and anterior portion of eye; origin of dorsal above second undivided or first divided anal ray; middle dorsal rays shortest, anterior portion falcate, posterior rays elongate and in the young extending upon caudal, but never as long as the highest anterior rays; anal falcate anteriorly, the first rays longer than the anterior dorsal rays; the middle and posterior anal rays much shorter and of nearly equal length; caudal forked, the lower lobe the longer, damaged in all my specimens; caudal peduncle flattened above, somewhat four-sided, its breadth equal to or a little less than its height; lateral line elevated on caudal peduncle, forming a more or less evident keel, especially on base of caudal fin; 23 or 24 scales between lateral line and origin of dorsal.

Greenish to deep green above, sides silvery, white beneath, a broad bright silver band from shoulder to base of caudal, top of head and upper jaw dusky or blackish, sides of head bright silvery, the toothed margin of lower jaw black; a black vertical mark on posterior margin of preopercle; posterior part of dorsal and middle of caudal blackish; pectorals and anal blackish posteriorly.

In alcohol the color is brownish or brownish gray above, silvery on sides, belly white or yellowish; fins yellowish or clear, more or less blackish posteriorly; middle of caudal blackish. Specimens in formalin show a blue-black stripe from shoulder to caudal base, much broader on posterior half.

Here described from the following specimens, 140 to 620 millimeters in length:

Manila, 3.
Calapan, Mindoro, 1.
Mangarin, Mindoro, 1.
Bacon, Sorsogon, 1.
Bantayan Island, 2.
Estancia, Panay, 2.
Culion, 2.
Dumaguete, 1.
Panacan, Palawan, 2.
Zamboanga, 1.
Sitankai, 1.

Jordan and Seale had specimens from southern Negros and Cavite; Evermann and Seale from Bacon, Sorsogon; and Jordan and Richardson from Manila and Iloilo. It is common in Philippine waters and is a food fish of some value.

This large species, which reaches a length of 1,200 millimeters, is perhaps the most widely dispersed of the East Indian species. It occurs from the Seychelles and the coast of India to North Australia, Samoa, and the Austral Islands, north to the Hawaiian Islands and Japan.

The name *giganteus* takes precedence over *annulatus*. My copy of Pisces, Fauna Japonica, is dated 1842. According to Sherborn and Jentink,[1] parts X to XIV, including pages 173 to 169, of Pisces, were published in 1846. In the same year Valenciennes published *annulata,* on page 332 in the edition used by me. As *gigantea* appears on page 245 it precedes Valenciennes's name.

TYLOSURUS PHILIPPINUS Herre. Plate 3.

Tylosurus philippinus HERRE, Philip. Journ. Sci. **35** (1928) 31, pl. 2.

Dorsal II–18, 19, or 20; anal II–18 or 19 or I–20; pectoral 14 to 15; ventral 6; lateral line about 194 + 10; about 22 scales between origin of dorsal and lateral line.

The compressed elongate body roughly pentagonal, head nearly triangular in cross section; depth 11.25 to 11.3 times in length, breadth of body 1.56 to 1.6 times in its own depth, which is greatest just before dorsal; head 2.88 to 2.93 times in length, its flat upper surface with a wide deep median scaleless channel and a small narrow elongate groove on each side of it; space between these and outer margin of interorbital with longitudinally divergent striæ; median channel narrows abruptly anteriorly and is prolonged in a narrow median groove to tip of beak; the large lateral eye placed high up, 9 to 10 times in head, 2.68 to 2.75 times in postorbital part of head, 1.25 to 1.375 times in interorbital, 6 to 6.25 times in snout; the strong mandible 1.36 to 1.44 times in head; extending beyond end of snout in a thick, spongy, somewhat flexible tip which rises above so that upper jaw rests upon it and dorsal profile of latter is continuous with that of lower jaw tip when mouth is closed; upper margin of mandible, except its fleshy tip, in line with middle of pupil of eye; mouth abundantly supplied with long, strong, needle-pointed vertical canines, those of lower jaw out-

[1] Proc. Zool. Soc, (1895) 149.

side upper jaw when mouth is closed; tongue smooth except margin of posterior constricted part, which has some hard tubercles; fourth upper pharyngeals not distinct from third; maxillary not entirely hidden by preorbital; preorpercle entirely covered with fine scales, opercle and top of head naked; pectorals broad, 3.3 to 3.5 times in head; ventrals a little shorter than pectorals, more or less falciform; origin of dorsal opposite first undivided anal ray; anterior dorsal and anal rays elongate, equal to or a fourth longer than pectoral, both fins boldly falcate, anal rays longest in two specimens, dorsal rays in another; height of dorsal 3 to 3.2 times, of anal 2.66 to 3.5 times in head; breadth of short caudal peduncle 1.6 times in its depth; the lower lobe of the lunate caudal much the longer, 2.4 to 2.5 times in head; lateral line forms a low keel on caudal peduncle.

Color in alcohol brownish above, silvery below, opercles and underside of head white; fins colorless except upper half of dorsal, which is more or less dusky, and central portion of caudal which is dusky to blackish at outer margin.

Known from four specimens, 390 to 462 millimeters long. The type and cotype are from Coron, Busuanga, one specimen is from Bato Bato, Tawitawi, and one from Sitankai.

This species differs notably from other representatives of the genus in Philippine waters.

TYLOSURUS CROCODILUS (Lesueur). Plate 4, fig. 2.

Esox belone FORSKÅL, Descr. Anim. (1775) 67, not of Linné.

Belone crocodilus LESUEUR, Journ. Acad. Nat. Sci. Phila. 2 (1821) 129; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 18 (1846) 327, pl. 549.

Tylosurus crocodilus FOWLER, Journ. Acad. Nat. Sci. Phila. 12 (1904) 501, pl. 9, upper fig.; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 128.

Strongylura crocodila FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Belone choram RÜPPELL, Neue Wirbelthiere, Fische (1835) 72; GÜNTHER, Cat. Fishes 6 (1866) 239; KLUNZINGER, Synopsis Fische des Rothen Meeres (1871) 578; DAY, Fishes of India (1878) 510 (not figure); GÜNTHER, Fische der Südsee 3 (1910) 351.

Tylosurus choram SEALE, Occ. Papers Bishop Mus. 4 (1906) 12 (doubtful).

Dorsal 22–23 according to authors, II–21 and 22 in my specimens; anal 19–21 according to authors, II–20 in my specimens; pectoral 1–13 lateral line about 270.

The breadth of the thick, robust, elongate body equals or is 1.25 times in its depth, which is 12.75 times in the length;

head very broad, strongly flattened above and on sides, 3.33 to 3.5 times in length; the large eye slightly elongate, 7.75 to 10 times in head, 2.25 to 3 times in postorbital region, 4.54 to 6.4 times in snout, and 1.375 to 1.7 times in the broad interorbital space; suborbital depth 1.9 to 1.35 times in eye, maxillary entirely hidden or its lower margin may be visible when mouth is closed; a wide shallow median groove on top of head, with a patch of scales at anterior end, and a narrow shallow groove on each side of it; supraorbital bone very finely striated; a conspicuous median groove on top of snout, the rest of its upper surface minutely pitted and roughened; preopercle scaled, opercle naked; canines large, strong, conical, erect, those of lower jaw outside upper jaw when mouth is closed, and very conspicuous; tongue entirely covered with rather large, hard, rounded tubercles; the broad pectorals equal to or a little shorter than postorbital portion of head; ventrals eight-ninths of pectorals, their base about midway between caudal base and anterior part of eye; origin of dorsal opposite base of first divided anal ray; dorsal and anal falcate anteriorly, middle and posterior rays much shorter, slender, and with prolonged tips, dorsal not extending to caudal, anal ending some distance before caudal; the lower lobe of the forked caudal the larger, 8.5 times in length, 1.45 times the postorbital part of head; caudal peduncle flatened above and below, its breadth nearly equal to its depth; lateral line forms a very slight keel on caudal base; 24 scales between origin of dorsal and lateral line.

Color in alcohol brown above, with a bluish dusky band from shoulder to caudal, yellowish brown below; pectorals dusky on outer half; other fins greenish yellow, dorsal with blackish margin.

Here described from a specimen 620 millimeters long, with damaged snout and caudal, from Tacloban, Leyte, and one 850 millimeters long, from Manila Bay. The Bureau of Science collection also contains a specimen 232 millimeters long, from Sitankai, and one 108 millimeters long, from Zamboanga. It is the bulkiest of the Philippine gars, and an important food fish at times.

This species reaches a length of more than 1,200 millimeters and occurs from the Red Sea and the east coast of Africa, through the Indian Ocean and the East Indies to the Bismarck Archipelago, the Solomon Islands, and Tahiti, north to Tonkin.

TYLOSURUS MELANOTUS (Bleeker).

Belone coromandelica VAN HASSELT, Alg. Konst. en Letterbode 1 (1823) 130 (nomen nudum).
Belone timucoides VAN HASSELT, Bull. de Férussac 2 (1824) Zool. 374 (no description).
Belone melanotus BLEEKER, Nat. Tijds. Ned. Ind. 1 (1850) 94; GÜNTHER, Cat. Fishes 6 (1866) 238; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 38; GÜNTHER, Fische der Südsee 3 (1910) 352.
Mastacembelus melanotus BLEEKER, Atlas Ichthy. 6 (1866–1872) 47.
Tylosurus melanotus FOWLER, Journ. Acad. Nat. Sci. Phila. 12 (1904) 501; WEBER and BEAUFORT, Fishes Indo-Aust. Arch. 4 (1922) 127, fig. 47.
Mastacembelus choram BLEEKER, Atlas Ichthy. 6 (1866–1872) pl. 256, fig. 1.
Tylosurus coromandelicus JORDAN and STARKS, Proc. U. S. Nat. Mus. 26 (1903) 530.
Strongylura coromandelica FOWLER, Proc. Acad. Nat. Sci. Phila. 71 (1919) 5.

Dorsal II–23 or 24; anal II–20 or 21; pectoral 1–11 or 12; lateral line about 300–350.

The elongate body strongly compressed, its breadth 1.45 to 1.7 times in depth, which is greatest just before ventrals and contained 13.3 to nearly 17 times in length; the broad head flattened above and on sides, 3.1 times in length; the large, slightly elongate eye very high, 9.1 to 9.7 times in head, about 7 times in the very long slender snout, 1.95 to 2 times in postorbital region, and equal or nearly equal to interorbital breadth; depth of mandible below eye about 3 times in longitudinal diameter of eye; maxillary entirely covered by preorbital when mouth is closed; top of head flat, much striated, with a very shallow and little developed median depression; preoporcle scaled, opercle naked except for a row or two of scales along its front margin; canines numerous, small, straight; tongue more or less covered with very small granular teeth; the broad pectorals equal or slightly exceed postorbital part of head; ventrals five-sixths of or nearly equal to postorbital region, their base about halfway between hind margin of eye and base of caudal; origin of dorsal above first divided ray in my specimens, anterior rays falcate and longer than the others, middle rays a little the shortest, last ray not quite reaching caudal base; anterior anal rays falcate, scarcely as long as anterior dorsal rays, the other anal rays much shorter and subequal; lateral line forms a more or less elevated dark or blackish keel on caudal peduncle; breadth of caudal peduncle equals its depth,

caudal forked, lower lobe much the longer, 1.33 to 1.66 times length of pectoral; 22 to 24 scales between lateral line and origin of dorsal.

Color in alcohol brown above, silvery on sides, the two colors sharply defined; in one specimen a dark blue band from shoulder to base of caudal and a similar, less well-defined line along median line of back; dorsal fin brown to blackish, anal brownish anteriorly, the rest of it with a dusky margin; outer half of pectorals more or less blackish; caudal dusky or yellowish; a blackish elongate spot on upper part of eye.

Here described from three specimens, one 455 millimeters long from Vigan, Ilocos Sur; one 610 millimeters long from Gingoog, Misamis Province, Mindanao; and one 505 millimeters long from Sitankai. Meyer recorded this species from Cebu.

This species occurs throughout the East Indies, north to Japan, and southeast to New Caledonia and North Australia.

SUMMARY OF THE PHILIPPINE GARFISHES DESCRIBED IN THIS PAPER

Family 1. BELONIDÆ

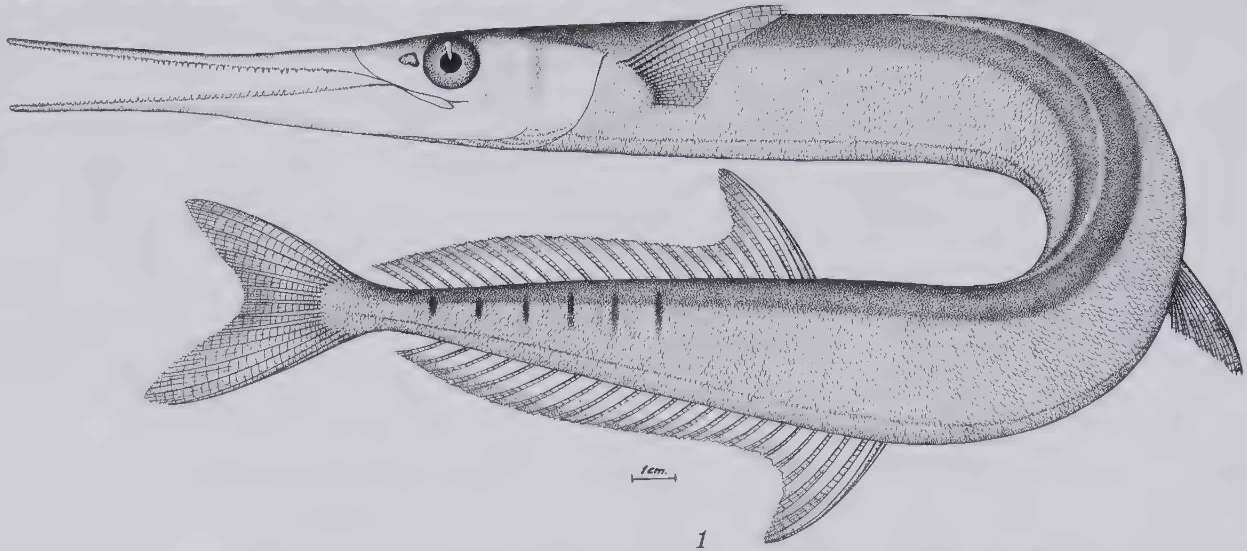
Genus 1. ABLENNES Jordan and Fordice

1. *Ablennes hians* (Cuvier and Valenciennes).

Genus 2. TYLOSURUS Cocco

2. *Tylosurus strongylurus* (van Hasselt).
3. *Tylosurus macrolepis* (Bleeker).
4. *Tylosurus incisus* (Cuvier and Valenciennes).
5. *Tylosurus leiurus* (Bleeker).
6. *Tylosurus giganteus* (Schlegel).
7. *Tylosurus philippinus* Herre.
8. *Tylosurus crocodilus* (Lesueur).
9. *Tylosurus melanotus* (Bleeker).

ILLUSTRATIONS



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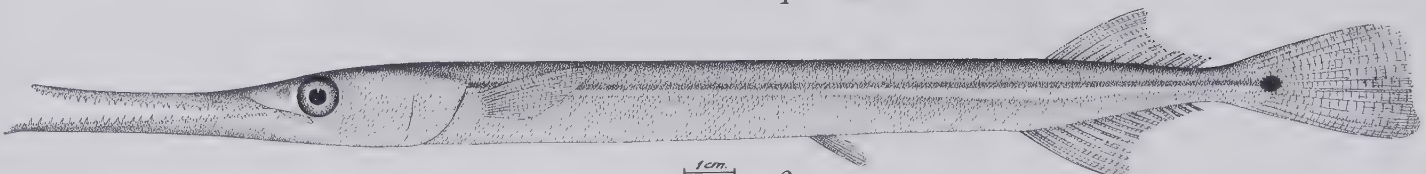

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PLATE 1.

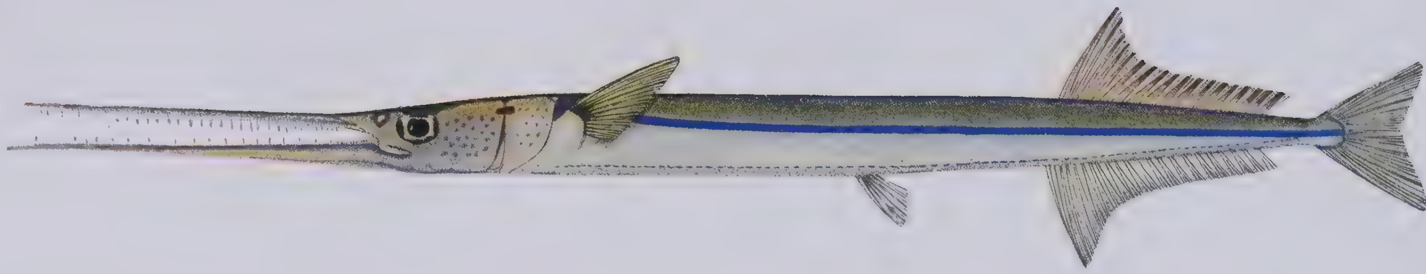

PLATE 2. TYLOSURUS LEIURUS (BLEEKER).

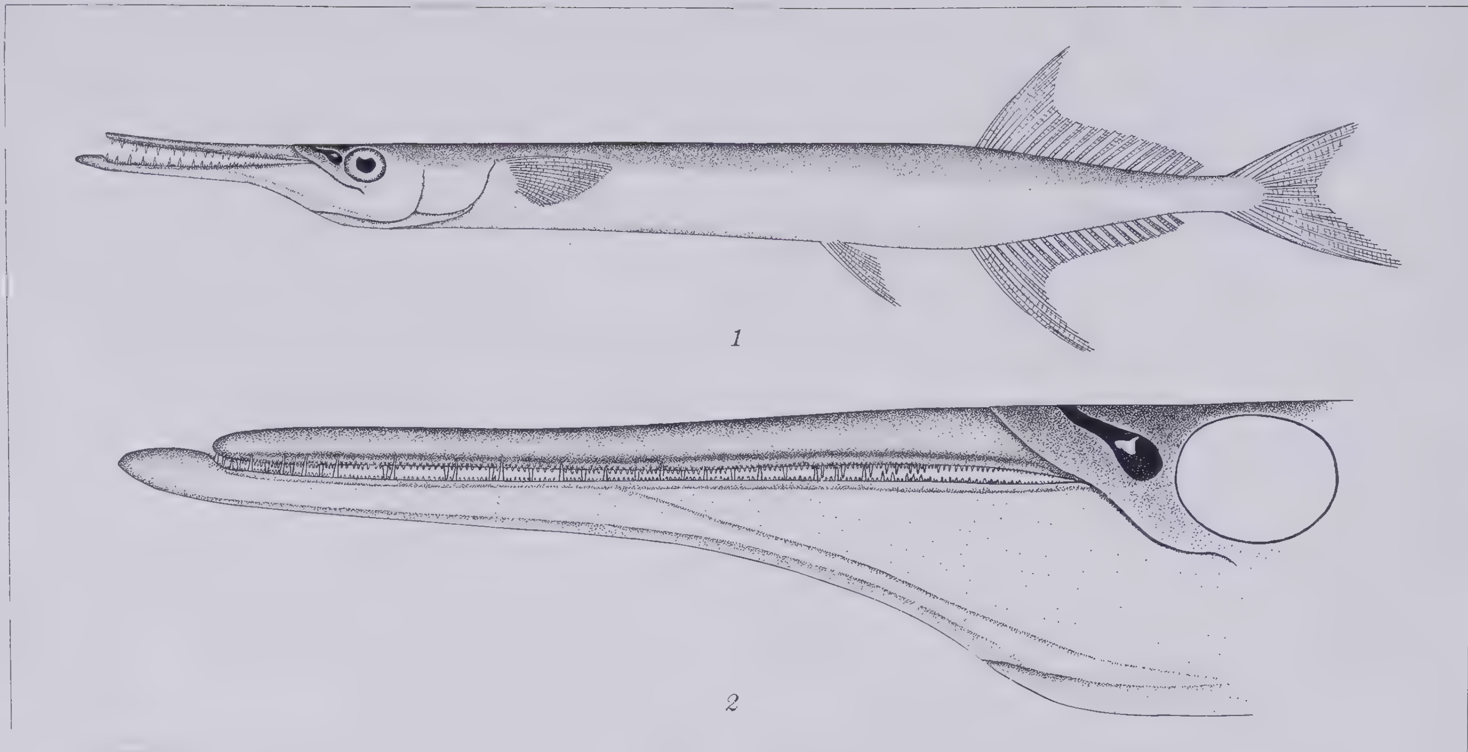

PLATE 3. TYLOSURUS PHILIPPINUS HERRE.

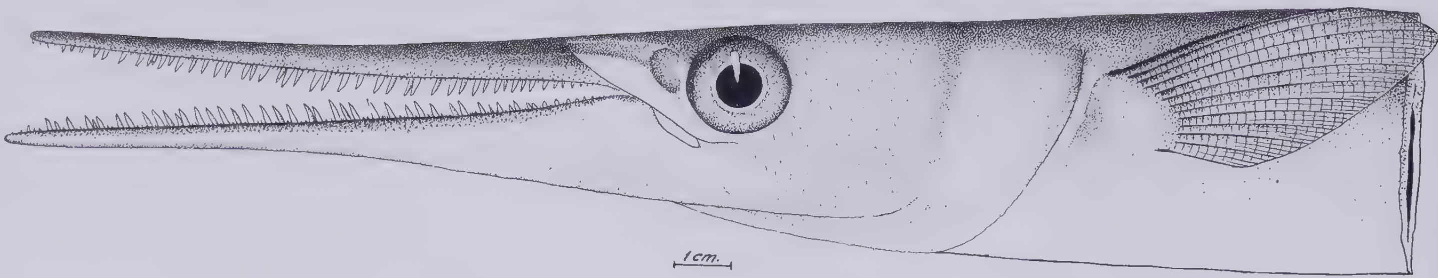

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PLATE 4.

COMPOSITION AND NUTRITIVE VALUE OF PHILIPPINE FOOD FISHES

By Abelardo Valenzuela

Of the Bureau of Science, Manila

Fish constitutes the principal protein food of a large majority of the people of the Philippine Islands. According to Herre,[1] approximately one-tenth of all the known kinds of fishes, or about 2,000 species, are found in Philippine waters. Most of these are edible.

SPECIES OF FISHES EXAMINED

Forty species of fresh fishes that are commonly found in the markets were examined. Some species were represented by more than one fish, like herring, snapper, etc. Table 1 is a list of the species of fishes that were analyzed in a fresh condition as they were purchased from various markets in Manila.

The following dried or smoked fishes were analyzed:

English name.	Tagalog name.
Slipmouth.	Sapsap.
Young mullet.	Talilong.
Goatfish.	Tuyo.
Anchovy.	Dilis.
Herring.	Tinapa, Tamban.

The following shellfishes were analyzed: Shrimps, lobsters, crabs, clams, and oysters; they are the ones most commonly eaten. Likewise, squid (pusit), and shrimp bagoong, a local sauce, were analyzed.

Calorific value.—The calorific or fuel value of each fish per 100-gram sample was obtained by using the standard physiological fuel values of the food constituents given by Rubner,[2] as follows: Carbohydrates, 4.1 calories per gram; fats, 9.3; protein, 4.1. The highest number of calories per 100 grams of the fish was obtained from the fish called mayamaya (red snapper), which gave 145.5 calories, and the lowest, 72.7 calo-

[1] Herre, Albert W., Fishery Resources of the Philippine Islands, Bureau of Science Popular Bull. 3 (1927) 9.

[2] Sherman, Chemistry of Foods and Nutrition (1918) 143.

TABLE 1.—*Names of fishes that were analyzed in a fresh condition.*

Serial No.	English name.	Tagalog name.	Scientific name.
1	Albacore, tuna	Tulingan	Thunnidæ.
2	Anchovy	Dilis	Engraulidæ.
3	Aso-os	Asohos	*Sillago sihama.*
4	Barracuda	Torsillo, babayo	Sphyraenidæ sp.
5	Basling, bastard shad	Kabasi	*Anadontostona chacunda* and *Konosirus thrissa.*
6	Billfish	Siriu (Ilocano)	Belonidæ.
7	Butterfly fish	Paro-paro dalag bukid	Chaetodontidæ.
8	Catfish	Kanduli	*Arius* sp.
9	Cavalla	Talakitok	Carangidæ.
10	Chub mackerel	Hasahasa	*Scomber microlepidotus.*
11	Climbing perch	Liwalo	*Anabas testudineus.*
12	Drepane	Mayang	*Drepane punctata.*
13	Eel, marine	Palos, pindanga	Ophichthyidæ.
14	Flounder	Dapa, palad	Pleuronectidæ.
15	Flathead	Sunog	Platycephalidæ.
16	Goby	Bia	*Glossogobius giruus.*
17	Grouper	Lapo-lapo	Serranidæ.
18	Grunt	Redillo, bisugo	Theraponidæ.
19	Herring	Tulis, tunsoy, siliñasi, tamban	Clupeidæ.
20	Jackfish	Talangtalang	Carangidæ.
21	Kingfish	Tanguingue	*Scomberomorus* sp. and *Acanthocybium* sp.
22	Leather jacket	Kassisung	*Scomberoides* sp.
23	Lizard fish	Kalaso	Synodontidæ.
24	Milkfish	Bañgos	Chanidæ.
25	Moray	Malabanos	Muraenidæ.
26	Mullet	Banak, talilong	Mugilidæ.
27	Murrel	Dalag, bakule	*Ophicephalus striatus.*
28	Pampano	Malapito, manipis, muslo	*Caranx* sp.
29	Parrot fish	Molmol	Scarichthyidæ.
30	Porgy	Bacoco	Sparidæ.
31	Red snapper, gray snapper	Mayamaya	Lutianidæ.
32	Sea bass	Apahap	*Lates calcarifer.*
33	Slipmouth	Hiwas, sapsap	Leiognathidæ.
34	Spadefish	Kitang	*Scatophagus argus.*
35	Surgeon fish	Indañgan, labahita, samaral	Acanthuridæ, *Siganus javus.*
36	Swordfish	Malasugi (Bicol)	*Xiphias gladius.*
37	Tarpon	Buan buan	*Megalops cyprinoides.*
38	Thread fin	Mamali	Polynemidæ.
39	----	Malakapas	*Xystaema abbreviatus.*
40	Ten-pounder	Bidbid	*Elops saurus.*

ries, from anchovy (dilis). Dried fishes gave very high calorific values, due to the highly concentrated condition of the fish.

Table 2 shows the composition of the different species of fresh fishes examined. There is great variation in the percentage of composition of moisture, fats, and protein. Carbohydrates were obtained by difference. In most of the samples, the carbohydrate content is nil, while in others it amounts to a very small quantity.

These differences may be attributed to various factors. According to Carter, Howe, and Mason,[3] the fat content of fish varies at the time of spawning, the different seasons of the year, and with changes in feeding conditions. Fishes are found to have deposited the maximum amount of fat just before the spawning season, and to have a minimum fat content a few weeks afterward. The food supply also affects the composition of fish. When they are forced away from their accustomed feeding grounds by storm or by natural enemies, they often arrive on our shores in a very lean condition.

Table 3 shows the composition of a few varieties of dried and smoked fishes analyzed. Attention is invited to the high protein and ash content. These fishes have been salted, and dried or smoked.

Table 4 shows the composition of some shellfishes (shrimps, lobsters, crabs, clams, and oysters) analyzed in order to compare them with fish. Shrimps are an important daily food of the Filipinos, either cooked alone or as an addition to vegetables and rice. Crabs, clams, and lobsters are likewise considered important sea foods, and have assumed a new importance in the light of nutrition studies.[4]

Fish is held to be more easily digested than other types of flesh food and meats. Estimation of its digestibility[5] shows that the protein is absorbed to the extent of 96 per cent, and the fats 97 per cent. It contains practically no carbohydrates. In mollusks, such as oysters, clams, and mussels, carbohydrates exist as glycogen.[5]

SUMMARY

1. The nutritive value of forty species of fresh fishes, six kinds of preserved fishes, and a few common shellfishes (crustaceans and mollusks) has been determined.

2. Fresh fish has an average protein content ($N \times 6.25$) of 20.15 per cent, while smoked or dried fish has as much as 44.92 per cent.

3. Fresh fish has an average fuel value of 99.02 calories, while smoked or dried fish has 237 calories per 100 grams.

4. Shrimps have 22.7 per cent protein and a fuel value of 98.8 calories per 100 grams; lobsters, 21.64 per cent protein

[3] Nutrition and Clinical Dietetics (1923) 202.

[4] McCollum and Simmonds, The newer knowledge of nutrition, Chap. IX p. 160.

[5] Carter, Howe, and Mason, Nutrition and Clinical Dietetics (1923) 204.

TABLE 2.—*Composition of Philippine food fishes.*

Fishes as found in the market.		Edible portion.	Refuse (entrails, skins, bones, etc.).	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extract).	Carbohydrates (by difference).	Ash.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		
Albacore, tuna	Tulingan	55.93	44.07	72.91	27.09	23.91	1.77	0.19	1.22	115.3	Fresh, edible portion analyzed.
Anchovy	Dilis			81.01	18.99	15.66	0.78	0.31	2.24	72.7	Eaten whole; entire fish analyzed.
Aso-os	Asohos	47.35	52.65	73.82	26.18	18.59	5.67	0.66	1.26	131.6	Fresh, edible portion analyzed.
Barracuda	Torsillo, babayo			77.29	22.71	20.09	0.77	0.43	1.42	91.3	Large fish; section analyzed.
Basling	Kabasi	47.06	52.94	77.03	22.97	19.36	1.67	0.28	1.66	96.0	Fresh, edible portion analyzed.
Bill fish	Siriu (Ilocano)	55.77	44.23	78.00	22.00	20.58	0.32		1.38	87.3	Do.
Butterfly fish	Dalag bukid	52.82	47.18	75.12	24.88	20.96	2.86		1.32	112.5	Do.
Catfish	Kanduli	43.22	56.78	81.09	18.91	17.16	0.16	0.55	1.04	74.1	Do.
Cavalla	Talakitok	52.65	47.35	76.86	23.14	21.44	0.66		1.29	94.0	Do.
Chub mackerel	Hasahasa	53.29	46.71	73.85	26.15	22.83	1.95	0.32	1.05	113.0	Do.
Climbing perch	Liwalo	35.93	64.07	78.62	21.38	18.69	1.60		1.09	76.4	Do.
Drepane	Mayang	36.30	63.70	78.51	21.49	18.96	1.32		1.22	90.0	Do.
Eel, marine	Palos			78.76	21.24	16.72	3.10	0.29	1.13	98.6	Large fish; section analyzed.
Flounder	Dapa, palad	52.00	48.00	76.81	23.19	19.98	0.97	1.08	1.16	88.6	Fresh, edible portion analyzed.
Flathead	Sunog	40.16	59.84	79.19	20.81	19.96	0.18		1.12	83.5	Do.
Goby	Bia	49.50	50.50	81.03	18.97	17.59	0.11	0.32	0.95	74.4	Do.
Grouper	Lapo-lapo			76.33	23.67	20.22	0.69	1.04	1.72	93.8	Large fish; section analyzed.
Grunt	Rodillo, bisugo	38.58	61.42	79.64	20.36	18.83	0.59		0.98	82.7	Fresh, edible portion analyzed.
Herring	Tulis	(a)	(a)	77.31	22.69	18.91	1.25	1.08	1.45	93.6	Eaten whole; entire fish analyzed.
Do	Tunsoy	(b)	(b)	71.32	28.68	20.39	3.58	2.74	2.07	128.1	Do.
Do	Siliñasi	(c)	(c)	74.36	25.64	19.13	2.63	0.22	3.66	103.8	Do.
Do	Tamban	28.6	71.4	79.16	20.84	19.12	2.70		1.01	103.5	Edible portion analyzed.
Jackfish	Talangtalang	49.9	50.1	77.15	22.85	20.90	0.21	0.39	1.35	89.2	Do.

Kingfish	Tanguingue	--------	--------	75.66	24.36	20.36	2.67	--------	1.32	108.3	Large, fish; section analyzed.
Leather jacket	Kassisung	52.03	47.97	77.65	22.35	20.28	0.07	0.48	1.52	85.7	Fresh, edible portion analyzed.
Lizard fish	Kalaso	61.64	38.36	79.17	20.83	19.40	0.45	--------	1.50	83.7	Do
Milkfish	Bañgos	70.56	29.44	73.80	26.20	19.24	5.57	0.10	1.29	131.1	Do.
Moray	Malabanos	(d)	(d)	77.71	22.29	19.08	1.28	--------	3.35	90.1	Eaten whole; entire fish analyzed.
Mullet	Banak	44.5	55.5	74.78	25.22	20.68	4.23	--------	1.23	124.0	Fresh, edible portion analyzed.
Young mullet	Talilong	30.00	70.0	77.20	22.80	20.15	2.65	--------	1.23	103.0	Do.
Murrel	Dalag	85.00	15.0	80.10	19.90	16.95	0.48	1.48	0.99	80.0	Do.
Pampano	Malapito	52.96	47.04	76.00	24.00	20.18	2.17	0.28	1.37	104.0	Do.
Parrot fish	Lorita, molmol	47.62	52.38	75.76	24.24	20.95	2.03	--------	1.46	104.7	Fresh, edible portion analyzed.
Porgy	Bacoco	46.40	53.60	77.37	22.63	19.87	0.63	0.74	1.39	90.4	Do.
Gray snapper	Mayamaya	58.33	41.67	78.26	21.74	17.62	1.57	1.33	1.22	92.3	Do.
Red snapper	do	--------	--------	72.72	27.28	18.44	7.42	0.24	1.18	145.5	Large fish; section analyzed.
Striped snapper	do	39.15	60.85	78.75	21.25	20.42	0.65	--------	1.21	89.8	Fresh, edible portion analyzed.
Sea bass	Apahap	67.00	33.00	74.81	25.19	20.77	1.94	1.03	1.45	89.5	Do.
Slipmouth	Sapsap	41.80	58.20	79.09	20.91	19.23	0.54	--------	1.28	83.8	Do.
Spade fish	Kitang	46.85	53.15	72.24	27.76	20.11	6.57	--------	1.08	143.5	Do.
Surgeon fish	Labahita, samaral	76.05	23.95	74.35	25.65	19.19	3.75	1.34	1.37	119.0	Do.
Swordfish	Malasugui (Bicol)	54.79	45.21	77.52	22.48	20.30	0.10	0.68	1.40	86.9	Do.
Tarpon	Buan buan	44.08	55.92	77.21	22.79	20.16	1.70	--------	1.13	84.2	Do.
Threadfin	Mamali	52.02	47.98	78.15	21.85	19.12	0.41	1.04	1.28	86.4	Do.
	Malakapas	41.49	58.51	75.48	24.52	21.01	2.02	0.18	1.31	105.6	Do.
Ten-pounder	Bidbid	55.57	44.43	79.15	20.85	19.37	0.29	--------	1.41	82.1	Do.
Young barracuda	Torsillo	59.40	40.60	78.56	21.44	18.74	0.34	1.10	1.26	84.5	Do.

[a] Average weight of each fish, 29.0 grams.
[b] Average weight of each fish, 29.3 grams.
[c] Average weight of each fish, 10.0 grams.
[d] Average weight of each fish, 8.8 grams.

TABLE 3.—*Composition of Philippine food fishes.*

Salted, dried and smoked fishes as found in the market.		Fishes analyzed.	Average weight of each fish.	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extract).	Carbohydrates (by difference).	Ash.		
		Per cent.	*g.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Slipmouth	Sapsap	12	20	41.39	58.61	45.64	2.46	-----	10.52	210.0	Salted, dried fish: edible portion analyzed.
Young mullet	Talilong	10	15.25	44.49	55.51	37.44	6.24	-----	12.20	211.5	Do.
Goatfish	Tuyo	12	9.80	42.63	57.37	40.74	4.09	-----	12.39	205.0	Do.
Anchovy	Dilis	20	1.55	20.69	79.31	67.49	3.30	-----	8.42	307.4	Do.
Herring	Tinapa	10	6.40	36.60	63.40	53.31	3.60	-----	7.04	252.0	Smoked fish; edible portion analyzed.
Milkfish	Bañgos	1	462.0	64.94	35.06	30.29	3.84		1.59	159.9	Roasted fish; edible portion analyzed.
Shrimp sauce	Bagoong alamang		-----	58.38	41.62	12.45	1.13	1.90	26.14	69.3	Salted, fermented shrimps analyzed.

TABLE 4.—*Composition of Philippine shellfishes.*

Shellfishes (crustaceans and mollusks) as found in the markets.		Edible portion.	Refuse (shell, bones, etc.).	Edible portion.						Calories per 100 grams.	Remarks.
English name.	Tagalog name.			Water.	Water-free substance.	Protein (N×6.25).	Fats (ether extracts).	Carbohydrates (by difference).	Ash.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Shrimp	Hipon	58.36	41.64	75.43	24.57	22.70	0.62	-------	1.63	98.8	Fresh, edible portion analyzed.
Lobster	Ulang	60.45	39.55	75.48	24.52	21.64	0.64	0.81	1.43	98.0	Do.
Crab	Alimango	48.63	51.37	80.07	19.93	12.79	5.04	-------	2.49	99.3	Do.
Small crab	Talangka	20.10	79.90	61.02	38.98	15.81	12.50	9.29	1.38	219.2	
Oyster	Talaba	19.25	80.75	87.97	12.03	6.76	1.26	3.44	0.57	53.5	Do.
Clam	Halaan	14.91	85.09	78.89	21.11	9.68	3.12	4.41	3.90	86.8	Do.
Squid	Pusit	98.16	1.84	76.46	23.54	18.39	0.52	3.00	1.63	80.2	Do.

and 98 calories; crabs, 12.79 per cent protein, 5.04 per cent fats, and 99.3 calories; clams, 9.68 per cent protein, 3.12 per cent fats, and 86.8 calories; oysters, 6.76 per cent protein, 3.44 per cent carbohydrates, and 53.5 calories; and squid (pusit), 18.39 per cent protein and 80.2 calories.

5. Plain roasted bañgos, or milkfish, has 30.29 per cent protein, 3.84 per cent fats, and 159.9 calories per 100 grams. Bagoong alamang, a partly fermented Filipino food made from small shrimps, has 12.45 per cent protein and 69.3 calories per 100 grams.

6. It is of great importance to know the dietary values of the various Philippine foodstuffs, so that it may be easily possible to make combinations that will provide highly nutritious diets for all classes of people.

PHILIPPINE LITTORAL ECHINOIDA

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SEVEN PLATES

This report on echinoids is based upon the littoral sea urchins and sand dollars in the collection of the Department of Zoölogy, University of the Philippines. The heart urchins are not included, as the few specimens in the collection are mostly broken and empty tests, probably picked up dead along sandy beaches. Collections are dated as early as 1913 and, as they have remained untouched for a long time, many of the specimens are now in a poor state of preservation. Credit is due to L. E. Griffin, R. P. Cowles, S. F. Light, and A. L. Day, who have contributed material to the collection.

This report is not meant to be a complete check list of Philippine littoral Echinoida, but is published in the hope that it may stimulate the interest of other workers and collectors. A much more extensive and intensive survey of Philippine waters is needed to bring this list to perfection. The aid of other workers and collectors is therefore solicited. All of the Philippine species of sea urchins and sand dollars have been described by specialists of other countries, and the types are deposited in foreign museums and laboratories. References to Echinoida of the Philippines are found in scattered papers dealing with larger areas or in general works, as in A. Agassiz's (1881) Challenger Echinoidea, Clark's (1925) Catalogue of Recent Sea Urchins in the Collection of the British Museum, and others. Most of these works are either out of print or inaccessible to most students. Philippine Echinoida are inadequately described and good illustrations are usually wanting. This paper may perhaps aid students and collectors in the Philippines to identify the material they find and enable foreign workers to determine whether or not the forms they have are identical with Philippine forms.

The echinoderms have not been observed to be as numerous in the Philippines as in temperate waters; but, as if to compen-

sate for this, the number of species is very large. At Puerto Galera, Mindoro, there are no less than eleven species of sea urchins and five of sand dollars. When this number is compared with two species of sea urchins and two of sand dollars found around the Marine Biological Station at Woods Hole, Massachusetts, the difference between the number of species found in tropical and in temperate waters is at once seen. Only three of the eleven species of sea urchins at Puerto Galera can be said to be abundant; these are *Tripneustes gratilla, Echinotrix calamaris*, and *Echinometra oblonga*. The others are rare and can be collected in very small numbers. The sand dollars are much less abundant. At Puerto Galera, Esanada seems to be the best collecting ground of *Arachnoides placenta* and *Ehinodiscus auritus*, and Medio Island toward the northwest channel for the two species of *Laganum;* yet none of these sand dollars appears in as great numbers as does the common sand dollar of the temperate waters of the American and Japanese coasts, *Echinarachnius parma.*

For purposes of identification living or freshly killed sea urchins and sand dollars are the best. I have found that the method recommended by Clark (1904) is the best. The animal is first narcotized by placing it in a solution of magnesium sulphate and then killed in 50 per cent alcohol or stronger. For preservation 70 per cent alcohol is used. To retain the typical color the animal should be killed in 50 per cent alcohol and then dried rapidly in the sun or by artificial heat, and care should be taken that the interior is saturated with alcohol before drying. Formalin should not be used, as it causes the tissues to swell and become slimy, and it dissolves the calcareous portions that are essential for proper identification. For the same reason, acid of any kind should be avoided. Pedicillariæ are best studied after they have been removed from the animal, soaked in a 10 per cent solution of potassium hydroxide, and mounted in glycerine or balsam.

The following is a list of Recent Echinoida reported by A. Agassiz (1881) with the Philippines as one of the principal localities where they were found:

GOMOCIDARIDÆ

Dorocidaris papillata.
Phyllacanthus annulifera.
Phyllacanthus baculosa.
Porocidaris elegans.

SALENIDÆ

Salenia hastigera.

ARBACIADÆ

Arbacia nigra.
Podocidaris prionigera.
Coelopleurus maillardi.

DIADEMATIDÆ

Diadema setosum.
Aspidodiadema tonsum.
Echinotrix calamaris.
Micropyga tuberculatum.
Astropyga radiata.

ECHINOTHURIDÆ

Asthenosoma gracile.
Asthenosoma grubii.
Asthenosoma pellucidum.
Asthenosoma tassellatum.
Phormosoma asterias.
Phormosoma luculentum.

ECHINOMETRIDÆ

Echinometra lucunter.
Echinometra oblonga.
Strongylocentrotus albus.
Pseudoboletia indiana.

TEMNOPLEURIDÆ

Temnopleurus hardwickii.
Temnopleurus reynadi.
Temnopleurus toreumaticus.
Prionechinus sagittiger.
Microcyphus zigzag.
Salmacis bicolor.
Salmacis rarispina.
Mespilia globulus.

TRIPLECHINIDÆ

Echinus angulosus.
Toxopneustes pileolus.
Hipponoe variegata.

CLYPEASTRIDÆ

Fibularia ovulum.
Clypeaster humilis.
Clypeaster scutiformis.

LAGANIDÆ

Laganum bonani.
Laganum depressum.
Peronella decagonalis.
Peronella peronii.

SCUTELLIDÆ

Echinodiscus auritus.

The following is a list of Philippine sea urchins and sand dollars in the collection of the British Museum of Natural History as reported by H. L. Clark (1925). The majority of these were collected during the voyage of H. M. S. *Challenger*, 1873 to 1876:

CIDARIDÆ

Prionocidaris baculosa, Zamboanga.
Prionocidaris verticillata, Mindoro.
Stylocidaris reini, east of Mindoro.
Stereocidaris grandis, north of Mindanao.
Discocidaris florigera, east of Mindoro.
Histocidaris elegans, no locality.

ASPIDODIAMETIDÆ

Micropyga tuberculata, off Cebu.

ECHINOTHURIDÆ

Phormosoma bursarium, northwest of the Philippines.
Echinosoma luculentum, near the Philippine Islands.
Asthenosoma varium, Zamboanga.
Araesoma gracile, no locality.
Araesoma pellucidum, near Cebu.
Araesoma tessellatum, near the Philippine Islands.

ARBACIADÆ

Pygmaeocidaris prionigera, Philippine Islands.
Coelopleurus longicollis, Basilan Strait.

TEMNOPLEURIDÆ

Prionechinus sagittiger, no locality.
Temnopleurus toreumaticus, Negros.
Salmacis bicolor, Zamboanga.
Salmacis dussumieri, near Zamboanga.
Salmacis sphaeroides, Cebu, Mactan Reef, Mindanao.
Mespilia globulus, Zamboanga.

ECHINIDÆ

Toxopneustes chlorocanthus, Masbate.
Toxopneustes pileolus, Siquijor, Zamboanga.
Tripneustes gratilla, Masbate, Zamboanga.

STRONGYLOCENTROTIDÆ

Pseudoboletia indiana, Zamboanga.
Pseudoboletia maculata, Zamboanga.
Evechinus chloroticus, Mindoro.

ECHINOMETRIDÆ

Echinometra mathei, Zamboanga.
Heterocentrotus mammillatus, Luzon, Negros.

CLYPEASTRIDÆ

Clypeaster humilis, no locality.

ARACHNOIDIDÆ

Arachnoides placenta, near Tabaco, Albay.

LAGANIDÆ

Laganum depressum, Siquijor, west of Panay.
Laganum laganum, Siquijor.
Peronella orbicularis, near Zamboanga.

In the key for the animals reported in this paper and in the descriptions of the various species the following terms and abbreviations are used: [1]

Abactinal system.—The group of plates at the apex of the test (or near the apex). The genital and ocular plates and, in true urchins, the anal plates compose this system.

Ambitus.—The largest horizontal circumference of the bare test.

Auricles.—Ossicles on the actinal edge of the test situated internally, which serve for the attachment of muscles controlling the movements of the Aristotle's lantern.

Compound plates.—Plates containing more than one elementary plate, primary and demi-plates. The number of elementary plates is shown by the number of pore pairs.

Coronal plates.—Any vertical series of plates running from the abactinal system to the peristome.

D.—Longest diameter of test.

Epiphyses.—A pair of ossicles connecting the upper ends of the alveoli of each pyramid of the Aristotle's lantern. Epiphyses are narrow when they do not meet each other above to form an arch.

Genital plates.—The five large plates at the abactinal end of the interambulacral areas.

Gill cuts.—Indentations of the test around the peristome, situated between the ambulacral and interambulacral areas.

H.—Height of test.

Imbricate plates.—Plates that are more or less overlapping.

Imperforate tubercles.—Tubercles without any central depression or vertical perforations.

Interporiferous areas.—Areas between the poriferous areas of the ambulacral regions.

Lunules.—Slitlike opening through the test, usually in the case of sand dollars and heart urchins.

Miliary spines.—The smallest spines found on the test, usually on very tiny tubercles.

Ocular plates.—Small plates of the abactinal system at the end of the ambulacral areas.

Petals.—The figures formed by the poriferous areas of the ambulacra, in sand dollars and heart urchins.

Poriferous areas.—Areas occupied by the pores of the tube feet.

Primary spines.—The largest spines on the largest tubercles.

Secondary spines.—Medium-sized spines, smaller than the primaries and larger than the miliaries.

Simple plate.—A plate containing one elementary plate (as shown by the number of pore pairs).

Sphæridia.—Small globular bodies on the oral surface. There are modified spines, supposed to be static in function.

[1] The terms used, their definitions, and the system employed in the descriptions are patterned after the work of H. L. Clark (1904).

Key to the Philippine littoral Echinoida.

a^1. Test more or less spherical, spines large or moderate, periproct at center of upper side, opposite mouth.

b^1. Ambulacral plates simple, peristome plated, sphæridia and peristomial gills absent.

c^1. Primary spines large and blunt with three or four whorls of projecting ridges, color, greenish................ *Prionocidaris verticillata.*

c^2. Primary spines small, without projecting ridges, but with small granules, color purplish.............................. *Prionocidaris baculosa.*

b^2. Coronal plates usually compound, forming two columns in each ambulacrum and each interambulacrum. Peristomial gills and sphæridia present.

c^1. Teeth grooved, primary tubercles perforate, epiphyses of lantern narrow.

d^1. Primary spines long, rough, and hollow.

e^1. Primary spines large, banded white and green, with numerous secondary tubercles on ambulacra........ *Echinotrix calamaris.*

e^2. Primary spines slender, extremely long, banded black and white or solid black, without secondary tubercles on ambulacra .... *Diadema setosum.*

d^2. Primary spines short, rough but more or less solid, banded purple and yellow.. *Astropyga radiata.*

c^2. Teeth keeled, epiphyses of lantern wide, primary tubercles imperforate.

d^1. Ambitus circular; ambulacral plates usually with three elements.

e^1. Test with pits on coronal plates; small; primary spines small.

f^1. Primary tubercles crenulate.................. *Salmacis sphaeroides.*

f^2. Primary tubercles not crenulate................ *Mespilia globulus.*

e^2. Test without sculpturing or pits; usually large; primary spines large.

f^1. Poriferous area not half as wide as interporiferous; pore pairs in arcs of three; spines green and white. *Toxopneustes chlorocanthus.*

f^2. Poriferous area more than half the interporiferous; pore pairs in three well-separated vertical areas; spines white or orange .... *Tripneustes gratilla.*

d^2. Ambitus more or less elliptical; ambulacral plates with more than three elements.

e^1. Pore pairs in arcs of four, spines tapering.

f^1. Test long, narrow, and high.................... *Echinometra oblonga.*

f^2. Test wide and flat.. *Echinometra picta.*

e^2. Pore pairs in arcs of eight to eleven, spines large, heavy, and stout; secondary spines truncated, flat topped. *Heterocentrotus mammillatus.*

a^2. Test flattened, spines minute; periproct outside the genito-ocular ring; more or less bilaterally symmetrical.

b^1. Test without marginal slits or lunules, size small.

c^1. Auricles separate.

d^1. Anus inframarginal, test flattened but concave orally; margin thick, genital pores five; petals nearly closed. *Clypeaster reticulatus.*

d^2. Anus supramarginal, test very flat; margin thin, genital pores four; petals straight and divergent........ *Arachnoides placenta.*

c^2. Auricles fused.

d^1. Test longer than wide; ambitus elliptical; anus much wider than long .... *Laganum depressum.*

d^2. Test roughly with circular ambitus; anus much longer than wide. *Laganum laganum.*

b^2. Test with two marginal slits, one at the end of each posterior petal, size large .... *Echinodiscus auritus.*

DESCRIPTIONS OF SPECIES

Family CIDARIDÆ J. Müller

PRIONOCIDARIS VERTICILLATA (Lamarck). Plate 1, fig. 2.

Cidarites verticillata LAMARCK, Anim. s. Vert. **3** (1816) 56.

Prionocidaris verticillata DÖDERLEIN, Abh. Senck. Nat. Ges. **34** (1911) 243; A. AGASSIZ, Rev. Ech. (1873) pt. 3; CLARK, The Cidaridæ, Mus. Comp. Zool. **51** (1907) No. 7, 187 (as *Phyllacanthus verticillata*); H. L. CLARK, Cat. Recent Sea Urchins (1925) 17.

Description.—Test regular, ambulacral plates simple; peristome plated; ambulacral plates extending to the mouth; no sphæridia and no peristomial gill present; test more or less flattened with a diameter between 28 and 32 millimeters and a height between 18 and 23; D = 1.6 H; periproct large with many plates covered with miliaries; genitals black and more or less rectangular; oculars green, covered with a few miliaries; entire abactinal system 14 to 15 millimeters, about one-half of the entire test diameter. Peristome somewhat smaller than abactinal system. Primary spines large, between 28 and 30 millimeters long, with an unspotted collar. These bear three to four axial whorls and one terminal whorl of projecting ridges; from nine to fifteen ridges in each whorl. Largest primary spines situated abactinally; those around the peristome smaller and without ridges. Secondary spines wanting. Miliaries flattened, mostly distributed around the bases of primaries. Two distinct rows of miliaries in each interporiferous area of the ambulacral region. Primary tubercles smooth and perforate, two rows of five or six in each interambulacral area. Tertiary tubercles fine and almost inconspicuous. Interambulacral areas about three times as wide as ambulacral areas at ambitus. Interporiferous areas as wide as poriferous. Pores straight or nearly so, connected with each other by a shallow groove.

Range—This species has been reported from British East Africa, Zanzibar, Mauritius, Chagos, Andaman Islands, Samoa, and the Philippines.

Remarks.—This species is rather rare and cannot be obtained in large quantities. Most of our specimens were obtained from Boaya Point, Puerto Galera, under stones or in the crevices of rocks. In life they are green. This color soon disappears in preserved specimens and the animal turns whitish yellow.

PRIONOCIDARIS BACULOSA (Lamarck). Plate 1, fig. 1.

Cidarites baculosa LAMARCK, Anim. s. Vert. 3 (1816) 55.
Prionocidaris baculosa MORTENSEN, Deutsch. Südpolar-Exp. Ech. (1909) 50; A. AGASSIZ, Rev. Ech. (1873) pt. 3, pl. 1, f, figs. 4, 5 (as *Phyllacanthus baculosa*).

Description.—Test rounded but very slightly flattened, ambitus circular; ambulacral plates simple; peristome plated; no sphæridia and no peristomial gills. Diameter of test, 18 to 25 millimeters; height, 11 to 16; D = 1.4 to 1.5 H. Periproct more or less pentagonal and bare; anal system 3 to 5 millimeters wide; boundary of abactinal system circular and 8 to 10 millimeters, about 0.44 to 0.48 of test diameter; longest spines, 20 to 33 millimeters. Genitals more or less rectangular, oculars triangular, both free from miliary spines. Peristome about the same in diameter as abactinal system. Primary spines more or less blunt, with purple lines on the collar. Greater length of primary spines usually covered by fine serrations arranged in fifteen or sixteen longitudinal rows. Longest spines dorsal around the abactinal system. Those around the peristome are more or less flattened with distinct longitudinal ridges around them. Secondary spines wanting; miliaries short and flat, arranged in circles around the primaries and in double rows in each interporiferous area. Peristome densely covered with minute miliaries. Primary tubercles smooth and perforate, arranged in double rows of five or six in each interambulacrum. Miliary tubercles almost insignificant. Interambulacral area about 3.2 times as wide as ambulacral. Pores horizontal or nearly so and yoked together by a shallow groove. Interporiferous area a little wider than poriferous.

In life *Prionocidaris baculosa* is purplish brown. The primary spines, when clean, have a purplish tinge banded with narrow, well-separated, whitish yellow lines. They may be covered with dirt at times and appear dirty white. The purple miliaries give the characteristic coloration to the animal.

Range.—This species has been reported from the Indian seas, Red Sea, and East Africa, Madras, Singapore, East Indies, Japan, Macclesfield Bank, and the Philippines.

Remarks.—I find this form to be extremely hard to classify, due to its variable features. Philippine specimens usually lack the white spots on the collar typical of *P. baculosa;* instead, we find longitudinal purple lines resembling *P. baculosa* var. *lineata* of Clark. However, the latter form is known only from the east coast of Africa, south of Mozambique, so that it is doubtful if Philippine specimens belong to this variety.

Family DIADEMATIDÆ Peters

DIADEMA SETOSUM (Leske). Plate 1, figs. 3 and 4; Plate 5, fig. 24.

Echinometra setosa LESKE, Add. ad Klein (1778) 36.
Diadema setosa GRAY, Ann. Phil. 10 (1825) 4; H. CLARK, Carnegie Inst. Mar. Bio. Papers (1921) 10, pl. 17, figs. 3, 4 (as *Centrechinus setosus*).

Description.—Test regular; ambulacral plates compound; coronal plates more or less imbricate; base of corona resorbed; peristome not plated; diameter of test, 34 to 50 millimeters; height of test, 16 to 22, D = 2.1 to 2.3 H; length of longest spines, 150 to 163 millimeters; diameter of anal system, 4 to 7 millimeters, 12 to 14 per cent of test diameter; diameter of entire abactinal system, 8 to 13 millimeters; diameter of peristome, 18 to 23. Test somewhat flattened, with a circular ambitus. Gill cuts shallow, but broad. Oculars small and insert except ocular I. Each bears two or three miliary spines. Genitals large, the madreporic plate largest and most prominent, black, and more or less rectangular. Ambulacra narrow and much narrower abactinally than at ambitus. Interambulacra broad, about three times as wide as ambulacra at ambitus. Poriferous areas narrow, about half as wide as interporiferous areas. Pore pairs in arcs of three ventrally, but in single pairs toward the abactinal system. Primary spines long and slender, longest at and above ambitus. Ambulacral and interambulacral primaries almost the same. Secondary spines few abactinally, mostly distributed actinally, and absent in ambulacra. Both primaries and secondaries fragile and hollow with twenty-four to thirty-two longitudinal series of teeth. Miliary spines evenly distributed throughout. Primary tubercles perforate. There are two rows in each interporiferous area of the ambulacra and four rows at each interambulacrum. Ambulacral primary tubercles smaller than interambulacral. Second series (inner pair) of interambulacral tubercles beginning on the seventh or eighth coronal plate. Secondaries forming a single row of widely separ-

ated tubercles on either side of the ambulacral areas; most numerous actinally. Miliaries forming a more or less irregular line between the primary tubercles.

In life the primary spines are black in old individuals, but with wide bands of white and black in young specimens. Abactinally the secondary spines are usually black, but actually they may have olive green bases, until they become entirely white (or whitish purple) around the peristome. Miliaries are black abactinally and white actinally. The anal tube is black with an orange yellow terminal end. Around the anal tube five purple dots are clearly visible in living specimens. In addition to this typical coloration, this species is easily differentiated from any other *Diadema* by the presence of five white spots at the interradii dorsally, just above the second series of interambulacral tubercles. The series of blue spots bordering the interambulacra, as pointed out by Clark (1921), usually can only be seen with great difficulty.

Range.—This is an Indo-Pacific species, having been collected in the Gulf of Suez, the Gulf of Akabah, the Gulf of Aden, Mauritius, East Africa, Ceylon, Singapore, Billiton, Macclesfield Bank, Japan, the Philippines, Java, Torres Strait, Australia, and Hawaii.

Remarks.—Next to *Echinotrix calamaris*, this species is the commonest poisonous sea urchin in the Philippines. It is found partly covered by rocks at low water to 36 fathoms.

ECHINOTRIX CALAMARIS (Pallas). Plate 2, figs. 5 and 6; Plate 5, fig. 23.

Echinus calamaris PALLAS, Spic. Zool. 1 fasc. 10 (1774) 31.
Echinotrix calamaris A. AGASSIZ, Rev. Ech. (1872) pt. 1, 119; DÖDERLEIN, Denkschr. Ges Gena 8 (1903) pl. 59, fig. 9, pl. 63, fig. 6; H. L. CLARK, Cat. Recent Sea Urchins (1925) 44.

Description.—Diameter of medium-sized test, 58 millimeters; height of test, 27; D = 2.15 H; length of longest spine, 75 millimeters; diameter of anal system, 8; diameter of the entire apical system, 15; diameter of peristome, 25. Test thin, flexible, and flattened, sloping slowly toward the ambitus, the latter more or less pentagonal in cross section. Actinal surface slightly resorbed and the peristome slightly sunken. Gill cuts shallow and broad. Peristome not plated, sphæridia and peristomial gills present. Central abactinal ambulacral areas depressed toward the apical system. Anal tube very conspicuous and in life bulging balloonlike out of the circumanal ring. It is usually spotted white, due to the presence of many small calcareous plates. Genital plates large; oculars small. The

black madreporite most conspicuous, as it is raised above the level of the other genitals. Interambulacra wide, about five times as wide as the ambulacra at the region of the ambitus. Ambulacral areas wider actinally than at ambitus. Pore pairs arranged in arcs of three. Primary spines situated in the interambulacral areas fragile and hollow, with a cavity more than half the diameter of the spine. Minute teeth arranged in separate whorls cover these spines.

The color in life is an alternation of white and green or white and brown, but these characteristic colors may change into a uniform black or uniform white in old specimens. The secondary spines located mostly in the ambulacral areas toward the aboral side are smooth except at the tips. They are yellowish green with purple tips due to the presence of a purple fluid in them. The miliary spines are scattered throughout. The bare depressed abactinal interambulacral areas of the test are apple green, while the rest of the test is light brown. Primary tubercles are perforate and are arranged in six to eight rows in each interambulacrum below the region of the ambitus. Secondary tubercles are also perforate and they form two to four rows in the interporiferous area of each ambulacrum.

Range.—This species has been reported from the Society Islands, East Indies, Kandavu Reef, the Philippines, Samoa, Fiji, Mauritius, Maldive Islands, Minokoi, Andaman, Macclesfield Bank, and Rotuma.

Remarks.—This species is rather common in Port Galera and is found most numerous in Honduras (Varadero Bay), Boaya Point, and Plateau among stones and eelgrass. It is famous for being beautiful but "poisonous." When touched the tips of the secondary spines break easily and remain embedded with their secretion under the skin of the hands or fingers. The "sting" is very painful and will remain so for several days unless the ends of the spines are removed and the fluid injected is neutralized with lemon, vinegar, or some other weak acid.

ASTROPYGA RADIATA (Leske). Plate 2, fig. 7.

Cidaris radiata LESKE, Add. ad Klein (1778) 52.
Astropyga radiata GRAY, Ann. Phil. 10 (1825) 4; PETERS, Abhandl. Akad. Berlin (1855) (1854) fig. 1 (as *A. mossambica*).

Description.—Diameter of test, 60 to 80 millimeters; height, 18 to 23 millimeters; D = 3 to 3.5 H; length of longest spines, 40 to 42 millimeters; diameter of anal system, 9 to 11; diameter of whole abactinal system, about 20; diameter of peristome, 24,

about 0.28 to 0.35 diameter of test. Test very thin and flexible and distinctly flattened, the extent of flattening depending upon the habitat of the animal during life or the pressure exerted during preservation. Actinal and abactinal surfaces flat; both the peristome and the abactinal system slightly sunken. Peristome not plated; peristomial gills and branchiæ present; gill cuts shallow but with thick border. Anal tube more or less conical, extending out of the circumanal ring; purplish with a black terminal surface. Circumanal ring composed of many small plates bearing small miliary spines. Oculars small and all exsert. Genitals large, more or less triangular, and each, with the exception of the madreporic plate, bearing a prominent black spot at the center. Ambitus more or less pentagonal, the interambulacra forming the sides, and the ambulacra the angles of the pentagon. Interambulacral areas four times as wide as ambulacral. Poriferous areas, which are almost as wide as the interporiferous, become slightly wider actinally. Pore pairs in arcs of three. Primary spines slender but short, with the central cavity filled with a calcareous network making the center of the spines look solid macroscopically. Minute teeth arranged in distinctly separated whorls cover these spines. In life they are distinctly banded with alternate purple and white, either throughout the entire length or at the base only; in the latter case, the tips may be uniform purplish black. Secondary spines similar but smaller and shorter. Miliaries very slender and fine. Primary tubercles perforate, arranged in eight to ten rows and two rows in the interambulacral and ambulacral areas, respectively. The outer rows of interambulacral tubercles (next to the poriferous areas) extend to the abactinal system, although here the tubercles may be much smaller. Between the two rows of tubercles next to the poriferous area and the other primary tubercles is a bare area in each interambulacrum, extending from the abactinal system. The coronal plates of these bare areas bear in life large, brilliant violet spots. There are twelve to seventeen of these spots on either side of each abactinal interambulacrum extending to the ambitus. Secondary tubercles are present on the interambulacra and ambulacra, alternating with the primaries. Miliaries scattered throughout.

Range.—This is an Indo-Pacific species and has been reported from British and German East Africa, Wasin Island, Mozambique, Mauritius, East Indies, the Philippines, and the Hawaiian Islands.

Remarks.—This species is very rare and most of our specimens were obtained at Calapan, among eelgrass and sand. This is the only *Astropyga* known from the Philippine Islands, and it cannot be mistaken for any other form due to the bright violet spots on the outer margin of the abactinal interambulacral plates.

Family TEMNOPLEURIDÆ Desor

SALMACIS SPHAEROIDES (Linné). Plate 3, figs. 10 and 11.

Echinus sphaeroides LINNÉ, Syst. Nat. ed. 10 (1758) 664.
Salmacis sphaeroides LOVEN, Bih. Svensk. Vet.-Akad. Handl. 13 (4), No. 5 (1887) 69; DÖDERLEIN, Denkschr. Ges. Jena 8 (1903) pl. 63, figs. 1–4*a*.

Description.—Average diameter of test, 60 millimeters; height, 38; D = 1.6 H, more or less; length of longest spines, 11 to 13 millimeters; diameter of anal system, 5 to 7; diameter of whole abactinal system, 10 to 12; diameter of peristome, 15 to 17. Test regular, with small pits between coronal plates; ambitus circular; abactinal side rounded, while the actinal surface is flattened with slightly sunken peristome. Gill cuts deep, with narrow everted edges. Anal plates numerous and largest toward genitals IV and V. All oculars, except II, exsert; genital plates small. Ambulacra slightly over half as wide as the interambulacra at the region of the ambitus. Poriferous area wide, about one-fourth as wide as an entire ambulacrum. Pore pairs arranged in three more or less vertical series. Spines fine and short and more or less uniformly distributed throughout; largest at the region below the ambitus. Primary and secondary spines with deep green bases with alternate bands of purple and light green or white toward the ends. Miliary spines white. Primary tubercles crenulate and imperforate, largest below the ambitus where there are four or five large tubercles in horizontal series on each coronal plate. Above the ambitus each coronal plate contains only one large primary tubercle. Each interambulacral plate contains, however, between four and nine subequal primary tubercles. A specimen with D = 59 millimeters, H = 38 millimeters, has thirty or thirty-one coronal plates. In life the animal as a whole is dark green. Bare tests are cream colored with a slight tinge of light purple.

Range.—Gulf of Siam, Billiton, Singapore, the Philippines, Australia, New Guinea, Queensland, and Solomon Islands.

Remarks.—The deep gill cuts and purple bands place this material without a question in this species. Our specimens

were collected by Mrs. R. S. Filoteo, on Mactan Reef, near Cebu, where the material in the British Museum was also collected.

MESPILIA GLOBULUS (Linné). Plate 2, figs. 8 and 9.

Echinus globulus LINNÉ, Syst. Nat. ed. 10 (1758) 664.
Mespilia globulus AGASSIZ and DESOR, Ann. Sci. Nat. III 6 (1846) 358; A. AGASSIZ, Rev. Ech. pt. 3 (1873) pl. 8*a*, figs. 13, 14.

Description.—Test regular, ambulacral plates compound with three elements; coronal plates with pits; base of corona not resorbed; peristome not plated; diameter of test, 38 to 45 millimeters; height of test, 29 to 33, D = 1.3 H; length of longest spines, 6 to 7 millimeters; diameter of anal system, about 3; diameter of entire abactinal system, 6 to 7; diameter of peristome, 11 to 12. Test high; ambitus circular; gill cuts shallow. Oculars small and all exsert; genitals larger, usually with eighteen secondary and miliary tubercles; ambulacral areas narrower than interambulacral; poriferous areas about one-third as wide as interporiferous; pore pairs medium in size, arranged in a continuous vertical series on each side near the margin of the ambulacra. Between the pore pairs and the margin of the ambulacra one or two miliary tubercles are present. Primary spines small, short, and slender, and confined at the meeting points of the ambulacral and interambulacral plates on either side of the pore pairs. Three or four spines on each side of an ambulacral and interambulacral plate. Median portions of the plates free from any spines at and above the ambitus. Pits situated at the inner edges of the ambulacral and interambulacral plates. Secondary and miliary spines aggregated around the primaries, especially numerous at the actinal side of the corona. Primary tubercles crenulate, usually three or four on each outer margin of the interambulacral and one or two on each ambulacral plate.

In life the test is olive green. The spines are greenish yellow or cream color with white and brown bands toward the tip. The spines around the actinostome have a tendency to be light gray or brown with white bands at the tip.

Range.—This species has been reported from Japan (Misaki), Korean Strait, Macclesfield Bank, Penang, the Philippines, Celebes, New Guinea, Loyalty Islands, and Samoa.

Remarks.—The species is small and delicate. It is rarely found on collecting trips. The material that forms the basis for the above description was collected by A. L. Day at Boco Island in 1913, and by R. P. Cowles and L. E. Griffin at Laoc,

Cavite, in 1915. The absence of any dark spines and the presence of oculars, which are all exsert from the anal system, place these specimens in this species without any doubt.

Family ECHINIDÆ Agassiz

TOXOPNEUSTES CHLOROCANTHUS Clark. Plate 3, figs. 12 and 13.

Toxopneustes chlorocanthus CLARK, Mem. Mus. Comp. Zool. 34 (1912) 283; H. L. CLARK, Cat. Recent Sea Urchins (1925) 522.

Description.—Large specimens have the test 107 millimeters in diameter, and 95 millimeters in height; D = 2.1 H. Spines small and short, the longest 10 to 15 millimeters; diameter of anal system, 4 to 7; diameter of whole abactinal system, 9 to 16; diameter of peristome, 24 to 33, about 0.35 of the diameter of test; test more or less flattened, curving slightly at first and then deeply to the ambitus, the latter circular; actinal side flattened with the peristome only slightly sunken; branchial incisions (gill cuts) long, deep, and with prominent interambulacral edges; many anal plates present, the largest toward genitals III and IV; ocular plates small, I and V insert, II, III, and IV usually exsert; genital plates larger, the madreporic plate the largest. All these plates, except the madreporic, bear miliaries. Ambulacra broad, about 0.8 interambulacra; poriferous areas narrow, much less than half of the interporiferous area; pore pairs in arcs of three. Spines numerous, all over the test; primaries green, white tips, pointed but not sharp. Spines more or less uniform in length, but slightly longer toward the actinostome, below the ambitus. Secondaries similar but shorter and smaller. Miliaries very small and white. Primary tubercles small and imperforate; in the ambulacral areas they are found on every other plate toward the poriferous area. In each interambulacral area there are two double or quadruple rows of white or yellow primary tubercles, each double or quadruple row surrounded by a row of secondaries at and below the ambitus. Miliary tubercles are very numerous on both the ambulacral and the interambulacral plates. A specimen with D = 75 millimeters and H = 28 has twenty-five coronal plates, while another with D = 107 millimeters has thirty-two coronal plates. The pedicillariæ are numerous and many of them stalked. Color in life is green; the test is light purple or green with transverse blotches of white, most noticeable around the abactinal system. Miliaries, pedicillariæ, and tube feet are white.

Range.—The range is very limited, this animal having been reported only from Samoa, Billiton, and the Philippines. The specimen in the British Museum is labeled *T. pileolus,* from Masbate.

Remarks.—This species is very scarce and its local range is not known. It is probably a deep-sea form and is encountered very seldom in shallow waters. Our largest specimens were obtained from Puerto Galera by L. E. Griffin in 1912, while the small ones came from the sand bars of Calapan, Mindoro. H. L. Clark, who described this species, doubts its validity and suggests that it may be a variation of *T. pileolus.*

TRIPNEUSTES GRATILLA (Linné). Plate 3, figs. 14 and 15; Plate 4, figs. 16 and 17.

Echinus gratilla LINNÉ, Syst. Nat. ed. 10 (1758) 664.

Tripneustes gratilla LOVÉN, Bih. Svensk. Vet. Akad. Handl. 13 (1887) (4) No. 5, 77; H. L. CLARK, Carnegie Inst. Mar. Biol. Papers 10 (1921) pl. 17, fig. 6; Cat. Recent Sea Urchins (1925) 124.

Description.—Diameter of medium-sized adult test, 65 to 72 millimeters; height of test, 35 to 45; $D = 1.5$ H; length of longest spines, 10 millimeters; diameter of peristome, 18 to 22, about 0.26 to 0.28 diameter of test; test regular, the greatest diameter below the ambitus; actinal surface more or less flattened, and the peristome only slightly sunken; gill cuts long and deep; anal plates numerous; ocular plates large, the two on either side of the madreporic plate (II and III) not touching the circumanal ring; genital plates larger, the madreporic plate largest; interambulacral regions almost as wide as ambulacral at ambitus, but become much narrower at abactinal region; interporiferous areas of ambulacra wider at ambitus than poriferous areas; pore pairs in three more or less well-separated vertical areas. Primary spines numerous, small, and slender, usually orange yellow, and longest around the ambitus. Secondaries almost as long, miliaries short and very fine. Primary tubercles imperforate; there are two rows present at each ambulacrum and interambulacrum above the ambitus and four rows below. Secondary tubercles most numerous at the actinal region, and few or wanting at the abactinal. Miliary tubercles found throughout. Between thirty and thirty-three coronal plates. Buccal membrane with numerous small plates.

Color in life is usually an alternation of purplish black at interambulacral and interporiferous regions due to the color of numerous pedicellariæ with whitish green at poriferous regions. The spines are usually orange yellow, while the tube feet are

white with a more or less dark purple basal part. Color variations exist, in the commonest the poriferous areas and spines are white. White and orange yellow spines may be found side by side in the same animal.

Range.—This species has been reported from the Red Sea, Suez Canal, German East Africa, Cape of Good Hope, Mauritius Islands, Rodriguez Islands, Borneo, Celebes, New Guinea, Australia, and the Philippines.

Remarks.—This species is very common at Puerto Galera and can be obtained in great numbers from Varadero Bay. The animals are found, when adult, on open intertidal bottoms with scanty eelgrass, but may be found also living hidden under rocks when very young. We find this species to be the best for class use. The largest specimens we have of *Tripneustes gratilla* were obtained from the sandy bar of Calapan. The bare tests of these measure 90 millimeters in diameter and 68 in height.

Family ECHINOMETRIDÆ Gray

ECHINOMETRA PICTA A. Agassiz and Clark. Plate 4, fig. 18; Plate 5, fig. 22.

Echinometra picta A. AGASSIZ and CLARK, Bull. Mus. Comp. Zool. 50 (1907) 241; H. L. CLARK, Mus. Comp. Zool. 34 (1914) No. 4, 373.

Description.—Test flattened, ambitus elliptical; long diameter of test, around 40 to 46 millimeters; width of test, 32 to 36, about 80 per cent test length; height, 18 to 21 millimeters, less than half of test length; gill cuts shallow; ocular plates V and I insert, II, III, and IV exsert; genitals seldom have more than one secondary tubercle; diameter of entire abactinal system about 0.20 of test length; interambulacral region almost twice as wide as ambulacral, and interporiferous areas also almost twice as wide as poriferous areas; pore pairs in arcs of four. Primary spines pointed and most numerous and longest around the ambitus. The width of the base of these spines is less than 0.10 of the length. Secondary spines are shorter and are most numerous below the ambitus. Those surrounding the peristome distinctly flattened. Miliary spines fine and evenly distributed around the primaries. Primary tubercles imperforated, two rows in each interambulacrum and interporiferous area. Secondary tubercles most numerous in the region below ambitus. Coronal plates ranging from twelve to fifteen. In life, the spines are fawn color or green with very light tips. The test is dark brown.

Range.—This species has been reported only from the Hawaiian, the Society, and the Philippine Islands.

Remarks.—*Echinometra picta* is very common in the Philippines, especially at Mariveles and in Mindoro. The animals are located in rock crevices, from which they are hard to remove. They appear together with *Echinometra ablonga* from which they can easily be distinguished by the wider and more-flattened test, and by the longer, more-tapering, and less-crowded spines. In a recent paper Clark (1925) suggests that *E. picta* may be an extreme variation of *E. matthei*. Measurements of Philippine specimens, however, agree with those of *E. picta*, which leads me to believe that *E. picta* is a valid species.

ECHINOMETRA OBLONGA de Blainville. Plate 4, figs. 19 and 20; Plate 5, fig. 21.

Echinus oblongus DE BLAINVILLE, Dict. Sci. Nat. **37** (1825) 95.
Echinometra oblongus DE BLAINVILLE, Dict. Sci. Nat. **60** (1830) 206; H. L. CLARK, Mus. Comp. Zool. **34** (1912) pl. 114, figs. 3, 1, and 2; Cat. Recent Sea Urchins (1925) 144.

Description.—Long diameter of test, 39 to 42 millimeters; width, 29 to 33, about 0.70 to 0.76 of test length; height of test, 20 to 23 millimeters, about 0.51 to 0.53 of test length. Length of longest spines, around 17 millimeters, with a diameter from 0.12 to 0.22 of spine length; all oculars exsert; genitals usually have only one secondary tubercle; diameter of entire apical system about 9 millimeters, or 0.22 of test length; diameter of peristome 0.20; test oblong in shape, narrow but high; gill cuts shallow and insignificant, but auricles prominent; ambulacral region wide, about 1.5 as wide as interambulacra; pore pairs in distinct arcs of four. Primary spines stout, tapering to a point; two rows of large ones in each ambulacrum and interambulacrum. Secondary spines are smaller and shorter, these most abundant below the ambitus. Those surrounding the peristome have a tendency to become flattened. Miliary spines tiny and scattered around the primaries of the interambulacra. All tubercles smooth, nonperforate, and large, and much more crowded than in *E. picta*, especially toward the actinal side. In life the spines are uniform light fawn, light green, or dark, while the test is brown. They can be distinguished from *E. picta* by their high oblong test and short, stout spines.

Range.—This species has been encountered in the Hawaiian Islands, Mauritius, Funafuti, and the Philippines.

Remarks.—Philippine specimens do not have the usual very stout spines of *E. oblonga*. The abactinal system is small with a greenish madreporite. The genitals usually have only one secondary spine. Like *E. picta, E. oblonga* is considered by Clark as a variation of *E. matthei*. As we have no specimen of the latter an accurate comparison cannot be made.

HETEROCENTROTUS MAMMILLATUS (Linné). Plate 5, figs. 25 and 26.

Echinus mammillatus LINNÉ, Syst. Nat., ed. 10 (1758) 667.
Heterocentrotus mammillatus BRANDT, Prod. Descr. Anim. (1835) 266; H. L. CLARK, Mem. Mus. Comp. Zool. 34 (1912) pls. 115–117.

Description.—Test regular, ambulacral plates compound with usually ten elements; long diameter of test, 45 to 55 millimeters; short diameter, 20 to 26; D = 2.2 H; length of longest spines, 75 millimeters; diameter of anal system, 7 to 10; diameter of peristome, 23 to 29; test somewhat flattened; ambitus elliptical; gill cuts shallow; oculars all exsert, each bearing one secondary tubercle; genitals large, madreporite largest, each bearing two to four secondary tubercles; ambulacra narrow, widest at the region of the ambitus; interambulacra wide, about twice as wide as ambulacra at ambitus; poriferous areas narrow, about half as wide as interporiferous; pore pairs in arcs of ten actinally, but this number may be reduced to eight abactinally. Primary spines long and heavy; longest and heaviest at or slightly above the ambitus. Interambulacral primaries larger than the ambulacral. Primary spines more or less circular in cross section at the base, but triangular toward the end, the three angles coming together at the tip. Actinal primary spines flatened and much smaller than the abactinal and ambital spines. Secondary spines small, short, flaring and truncated at tip; most numerous at and around the abactinal system. Smaller and flattened secondary spines are found on the peristomial membrane, arranged in five groups, each group corresponding with an ambulacral region. Primary tubercles few, heavy, and nonperforate; usually seven or eight pairs in each ambulacrum and interambulacrum. Ambulacral primary tubercles aggregated toward the actinal side. Secondary tubercles also nonperforate. Most of them are located at or toward the abactinal side of the test.

In life the spines are deep purple or red, the redness most distinct at the tips. Large primary spines have narrow white bands toward the end. These white bands range from one to

as many as five on each spine. The smaller spines are solid red or deep purple. Tube feet are large and, in preserved specimens, white, most easily visible toward and around the peristome.

Range.—This species has been reported from the Red Sea, German East Africa, Rodriguez, Mauritius, the Philippines, the Bonin Islands, New Guinea, the Loyalty Islands, and the Fiji and Hawaiian Islands.

Remarks.—The only other species of *Heterocentrotus* known is *H. trigonarius*, most frequently met with around the southern Pacific Islands. Many of our specimens of *H. mammillatus* in spines and coloration resemble *H. trigonarius*, but the number of pore pairs (usually 10) and the flat-topped secondary spines of our specimens place them without any doubt in *H. mammillatus*. The majority of our examples of this species were collected from the Northwest Channel and Small Balatero Cove, near Puerto Galera, Mindoro.

Family CLYPEASTRIDÆ Agassiz

CLYPEASTER RETICULATUS (Linné). Plate 6, figs. 27 and 28.

Echinus reticulatus LINNÉ, Syst. Nat. ed. 10 (1758) 666.
Echinodiscus reticulatus LESKE, Add. ad Klein (1778) 143.
Clypeaster reticulatus DESMOULINS, Etude sur les Ech. Tab. Syn. (1837) 214; LAMARCK, Anim. sans Vert. 3 (1816) 14; A. AGASSIZ, Rev. Ech., pt. 4 (1874) pl. 13 f, figs. 1, 2 (as *C. scutiformis*).

Description.—Test small, flattened, but strongly concave on the oral side; auricles separate; margin thick, swollen and distinct from the petaloid area; test uniformly covered with closely set fine secondary spines and larger and fewer primary spines. Test with brown spottings, more intense on the actinal side. Petals wide and short, and all practically closed. Usually less than thirty pore pairs on each side of a petal and usually two primary tubercles in the ridges between pore pairs. Marginal ends of petals depressed, below the level of the margin, although the apical system is much elevated. Five genital pores very close to the madreporite. Actinostome at the center of the concave oral side, anus inframarginal. Grooves marking the ambulacra on the ventral side inconspicuous and not extending to the periphery.

A medium-sized specimen has the following measurements: Long diameter, 55 millimeters; longest transverse diameter, 35;

vertical diameter, 120; diameter of abactinal system, 3; length of anterior petal, 14; length of posterior petal, 14; length of longest spines (around mouth), 3. Petaloid area about 28 millimeters long, 63 per cent of test length. Petal I slightly longer than III and V and much longer than petals II and IV, which are the shortest. Width of petals from 47 per cent (long petals) to 72 per cent (short petals) of the length.

Range.—This species has been reported from Suez, Red Sea, British East Africa, Durban Bay, Mauritius, Seychelles, Mascarenes, Providence Island, Saya de Malha, Macclesfield Bank, Boluthuria Bank, and the Hawaiian and Philippine Islands. The bathymetrical range is from 13 to 253 fathoms.

Remarks.—This species is commonly found in shallow waters. Our collection includes material from Puerto Galera, collected by L. E. Griffin, 1912.

Family ARACHNOIDIDÆ Gregory

ARACHNOIDES PLACENTA (Linné). Plate 7, figs. 33 and 34.

Echinus placenta LINNÉ, Syst. Nat. ed. 10 (1758) 666.
Arachnoides placenta AGASSIZ, Mon. Echin. Mon. Scut. (1841) 94; MORTENSEN, Vid. Medd. (1921) 73, pl. 6, figs. 21, 27; H. L. CLARK, Cat. Recent Sea Urchins (1925) 154.

Description.—Test flattened discoidal; margin thin; abactinal surface slightly convex, actinal surface flat; auricles separate; test covered with closely arranged fine spines, shortest and most uniform abactinally and longest actinally. Longest spines situated at interradial areas toward the margin. Ambulacral areas on the abactinal side elevated toward the center of the test. Poriferous areas of petals straight and divergent, extending about halfway to the margin. Actinally a deep, straight, unbranched furrow appears at the center of each ambulacrum which is slightly wider toward the actinostome. This groove extends abactinally and reaches almost to the abactinal system. Abactinal interambulacra slightly depressed and each composed of two rows of plates. Only one pair of plates on the dorsal side, at the margin of the test in each interradius. Interambulacra about one-third as wide as the ambulacra at the margin. Abactinal system central; genital pores four; anal opening supramarginal (abactinal side of margin). A large specimen has the following measurements: Longitudinal diameter, 58 millimeters; transverse diameter, 59; vertical diameter, 8; diameter

of abactinal system, 24; length of anterior petal, 18; length of posterior petal, 17; length of spines at margin, 2; length of spines at peristome, 2. The greatest transverse diameter passes through the abactinal system. The width between the outer borders of the petals varies from 0.18 to 0.22 per cent of the test length. In life, the animal is yellowish green on both sides. Bare unbleached tests are dark brown abactinally and very light brown actinally.

Range.—The principal localities in which this species is found are the Andaman Islands, the Philippines, New Britain, Torres Strait, and Australia.

Remarks.—This is the commonest sand dollar found at Puerto Galera. The animals are most abundant at Esanada on fine sand just above the eelgrass line. They are large enough for class study of the test of sand dollars, but cannot be used for the study of internal structures.

Family LAGANIDÆ A. Agassiz

LAGANUM DEPRESSUM A. Agassiz. Plate 6, figs. 31 and 32.

Laganum depressum A. AGASSIZ, Mon. Ech., Mon. Scut. (1841) 110, pl. 23 figs. 1–7; H. L. CLARK, Rev. Recent Echinoderms (1921) 157.

Description.—Test with a more or less pentagonal ambitus, length much greater than width; test flat, but with a slightly thickened margin and with a broad shallow depression between the margin and the abactinal system; auricles fused into a single piece on the interambulacrum; body covered with spines, short and dense abactinally, long and sparse actinally; test smooth dorsally and slightly rough ventrally. The ambulacra distinct dorsally, with prominent, practically close, petaloid areas. Usually two or three primary tubercles on ridges between pore pairs. Actinally the ambulacral areas are marked by shallow furrows extending more than halfway to the margin. Abactinal system and peristome slightly anterior to center of the test. Genital pores five. Anal opening actinal, nearer the margin than the peristome, and much wider than long. A medium-sized individual has the following measurements: Longitudinal diameter, 48 milimeters; longest transverse diameter (across peristome), 40; vertical diameter, 6; diameter of abactinal system, 5; length of anterior petal, 15; length of posterior petals, 14.5; length of longest spine, 3.

Petaloid area large, about 62 per cent of the test length. Petals I, III, and V almost the same in length, and longer than petals II and IV. Width of petals variable, ranging from 34 to 50 per cent of length. In life uniform light olive yellow on both sides; bare unbleached tests pale yellow. On the actinal side a fine tuberculation can be seen.

Range.—This species has been collected from the following points: Gulf of Suez, Red Sea, East Africa, Zanzibar, Mauritius, Amirantes, Maldives, Gulf of Manaar, Singapore, Macclesfield Bank, Philippines, Torres Strait, and Tongatabu, Australia. It is found at low tide level to 48 fathoms on sand or mud.

Remarks.—This species is known to grow as large as 80 by 72 by 7 millimeters, but Philippine specimens are usually of the size described above. Some specimens without genital pores and others with six pores have been reported.

LAGANUM LAGANUM (Leske). Plate 6, figs. 29 and 30.

Echinodiscus laganum LESKE, Add. ad. Klein (1778) 140.
Laganum laganum DE BLAINVILLE, Dict. Sci. Nat. 60 (1830) 196; A. AGASSIZ, Rev. Ech. pt. 3 (1873) pl. 13*e*, figs. 6, 7 (as *Laganum bonani*); CLARK, Cat. Recent Sea Urchins (1925) 158.

Description.—Test flat but thick and more or less pentagonal in outline, and slightly longer than wide; auricles fused; test white or with brown spots, covered with uniformly distributed short small white spines; a few longer spines surrounding the peristome; margin elevated and petaloid area slightly sunken; petals not quite close at ends. Usually only one or two primary tubercles on the ridges between pore pairs. Five genital pores, close to the madreporite at the center of the test. On the oral surface, the ambulacral areas marked by narrow deep grooves, most prominent in their inner portions next to the peristome. Alternating with these are five wide, very shallow depressions of the test, widest and easily visible at the margin. Anal opening about midway between mouth and margin and almost twice as long as it is wide.

An average-sized animal has the following measurements: Longitudinal diameter, 36 millimeters; longest transverse diameter, 33; vertical diameter, 6; diameter of abactinal system, 2; length of longest spines, 1.5.

Petaloid area large, about 68 per cent of test length. Anterior petals II, III, and IV practically the same in length and

slightly shorter than posterior petals (I and IV). Width of petals from 30 to 40 per cent of length.

Range.—The range of this species extends from the Philippines east to the Carolines and south to Tasmania; the species is represented in the British Museum by specimens collected from the Indo-Pacific area, eastern seas, the Philippines, Siquijor, Timor Laut, West Australia, and Dirk Hartog Island.

Remarks.—Specimens as large as 46 by 44 by 9 millimeters have been reported, but most of our specimens are about 36 by 33 by 6.5 millimeters. Spotted and unspotted individuals are collected together in many places, and they do not seem to differ except in spotting. This species is very common at Taytay, Palawan, where most of our specimens were collected by S. F. Light in 1913.

Family SCUTELLIDÆ Agassiz

ECHINODISCUS AURITUS Leske. Plate 7, figs. 35 and 36.

Echinodiscus auritus LESKE, Add. ad. Klein (1778) 138; A. AGASSIZ, Rev. Ech., pt. 3 (1873) pl. 13*c*, figs. 1, 2.

Description.—Test very flat; margin thin with two long marginal slits situated in each posterior ambulacrum; auricles fused, situated on the interambulacrum; test covered with minute spines, shortest and most uniform abactinally and longest and most variable in length actinally, the longest at the edge of test and on interradial areas around the peristome. Abactinally, the ambulacra very distinct, with poriferous areas in the form of closed petals extending halfway to the margin of the test. Petal III (anterior) longest, and II and IV longer than I and V. Actinally, the five ambulacra appear as deep furrows around the peristome. About 6 or 7 millimeters from the peristome, each furrow splits into two primary branches which extend almost to the margin. About halfway between the peristome and the margin a secondary branch, also extending almost to the margin, is given off from each of the primary branches at an angle between 85° and 90° toward the interambulacra. Posterior primary branches may give off more than one secondary branch. Both main and secondary branches give off small tertiary branches mostly toward the interambulacra. No furrows extend abactinally. The abactinal system is approximately central and there are four genital pores. The anal opening is actinal, between the two posterior ambulacra, nearer the margin than the peristome.

Our specimens are more or less uniform in size, the test often longer than wide. These have the following measurements: Longitudinal diameter, 116 to 122 millimeters; transverse diameter (through peristome), 107 to 118; vertical diameter, 7 to 10; diameter of abactinal system, 6 to 7; length of anterior petal, 32; length of posterior petals, 25; length of longest spine, 4.

The peristome and the abactinal system are usually a little in front of the center of the test, and the longest transverse diameter is posterior to the center, between the peristome and the inner angle of the marginal slits. Thus, a specimen with 110 millimeters as a transverse diameter (across the abactinal system) has 121 millimeters as the longest transverse diameter. The greatest width of the petals is usually between 0.62 and 0.72 per cent of the longitudinal test diameter. In life, the abactinal side is grayish, while the actinal side is yellowish gray with very pale yellow lines marking the partitions between plates. Bare tests are purplish with a dirty white region between the halves of the petals abactinally and at the interambulacra around the peristome actinally.

Range.—This species has been reported from Suez, Red Sea, Persian Gulf, East Africa, Mombosa, Zanzibar, Mauritius, India, Madras, and the Philippines.

Remarks.—We find this species to be most abundant in Esanada, Puerto Galera, Mindoro, on sandy shores above the eelgrass line, on the same type of substratum as that on which *Arachnoides placenta* is found. At low water the animals can be seen half buried under the sand.

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ILLUSTRATIONS

[All photographs were prepared by Mr. Juan Fontanoza, of the Bureau of Forestry.]

PLATE 1

FIG. 1. *Prionocidaris baculosa* (Lamarck); aboral side, $\times \frac{6}{7}$.
2. *Prionocidaris verticillata* (Lamarck); dorsolateral view, $\times \frac{6}{7}$.
3. *Diadema setosum* (Leske); aboral side, $\times \frac{3}{7}$.
4. *Diadema setosum* (Leske); side view, $\times \frac{3}{7}$.

PLATE 2

FIG. 5. *Echinotrix calamaris* (Pallas); aboral side; most of the spines are broken and only basal halves remain, $\times \frac{1}{2}$.
6. *Echinotrix calamaris* (Pallas); oral side, $\times \frac{1}{2}$.
7. *Astropyga radiata* (Leske); aboral side of a much distorted small specimen, $\times$ 1.
8. *Mespilia globulus* (Linné); aboral side of a whole animal, $\times$ 1.
9. *Mespilia globulus* (Linné); aboral side of bare test showing pits on coronal plate, $\times$ 1.

PLATE 3

FIG. 10. *Salmacis sphaeroides* (Linné); aboral side, $\times \frac{2}{3}$.
11. *Salmacis sphaeroides* (Linné); oral side, $\times \frac{2}{3}$.
12. *Toxoneuptes chlorocanthus* Clark; whole animal, aboral side, $\times \frac{1}{2}$.
13. *Toxoneuptes chlorocanthus* Clark; bare test, aboral side, $\times \frac{1}{2}$.
14. *Tripneustes gratilla* (Linné); aboral side of bare test, $\times \frac{2}{3}$.
15. *Tripneustes gratilla* (Linné); oral side of bare test, showing deep gill cuts, $\times \frac{2}{3}$.

PLATE 4

FIG. 16. *Tripneustes gratilla* (Linné); aboral side of whole animal, $\times \frac{2}{3}$.
17. *Tripneustes gratilla* (Linné); oral side of whole animal, $\times \frac{2}{3}$.
18. *Echinometra picta* A. Agassiz and Clark; aboral side of an exceptionally large specimen, $\times \frac{1}{2}$.
19. *Echinometra oblonga* (de Blainville); aboral side, $\times$ 1.
20. *Echinometra oblonga* (de Blainville); oral side, $\times$ 1.

PLATE 5

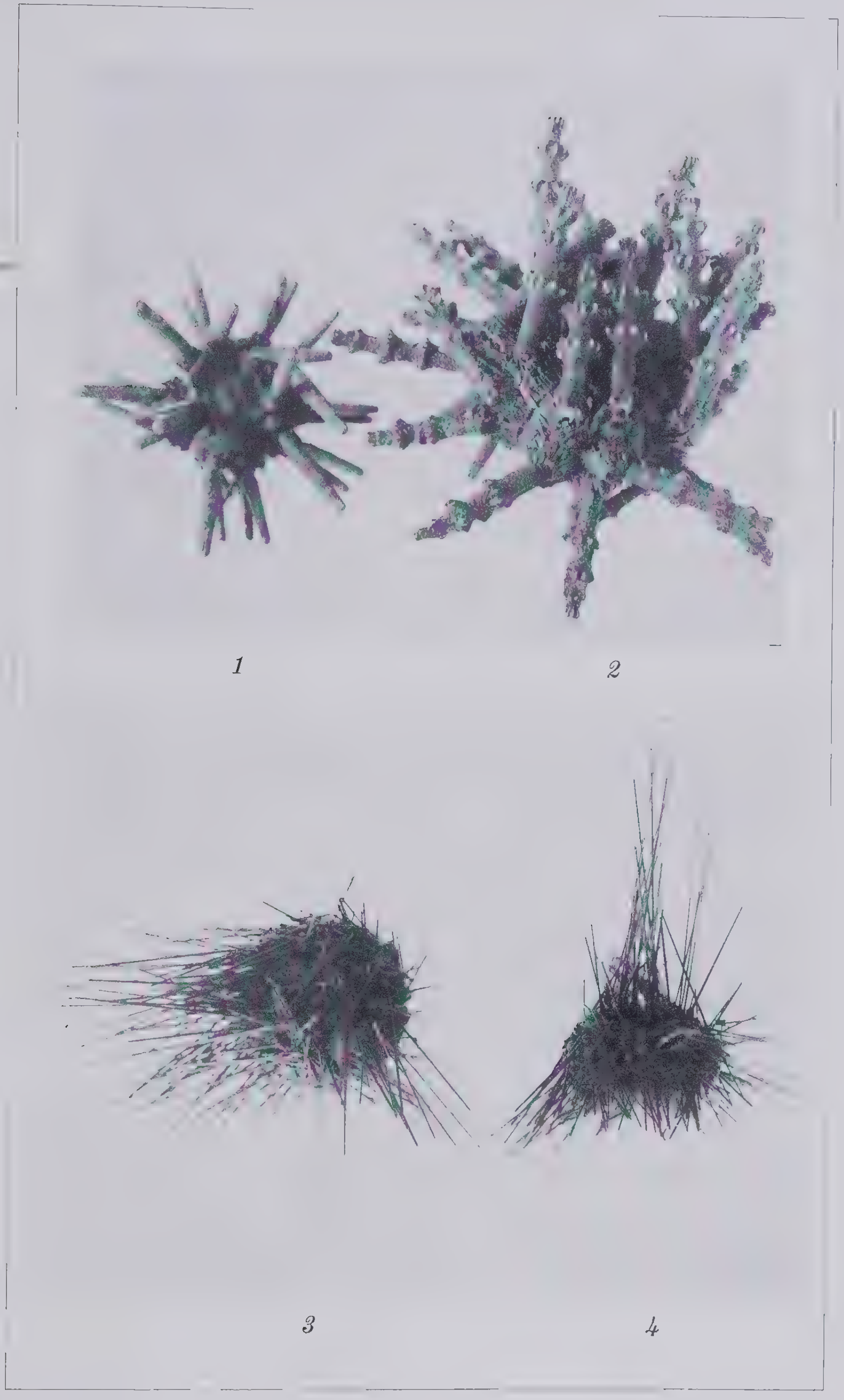
FIG. 21. *Echinometra oblonga* (de Blainville); bare test, aboral side, $\times$ 1.
22. *Echinometra picta* A. Agassiz and Clark; bare test, aboral side, $\times$ 1.
23. *Echinotrix calamaris* (Pallas); bare test, aboral side, $\times$ 1.
24. *Diadema setosum* (Leske); bare test, aboral side, $\times$ 1.
25. *Heterocentrotus mammillatus* (Linné); oral side, $\times \frac{5}{8}$.
26. *Heterocentrotus mammillatus* (Linné); aboral side, $\times \frac{5}{8}$.

PLATE 6

FIG. 27. *Clypeaster reticulatus* (Linné); oral side, × 1.
28. *Clypeaster reticulatus* (Linné); aboral side, × 1.
29. *Laganum laganum* (Leske); bare test, aboral side, × 1.
30. *Laganum laganum* (Leske); bare test, oral side, × 1.
31. *Laganum depressum* A. Agassiz; bare test, aboral side, × 1.
32. *Laganum depressum* A. Agassiz; bare test, oral side, × 1.

PLATE 7

FIG. 33. *Arachnoides placenta* (Linné); whole animal, aboral side, × 1.
34. *Arachnoides placenta* (Linné); bare test, oral side, × 1.
35. *Echinodiscus auritus* Leske; bare test, oral side, × 1.
36. *Echinodiscus auritus* Leske; bare test, aboral side, × 1.



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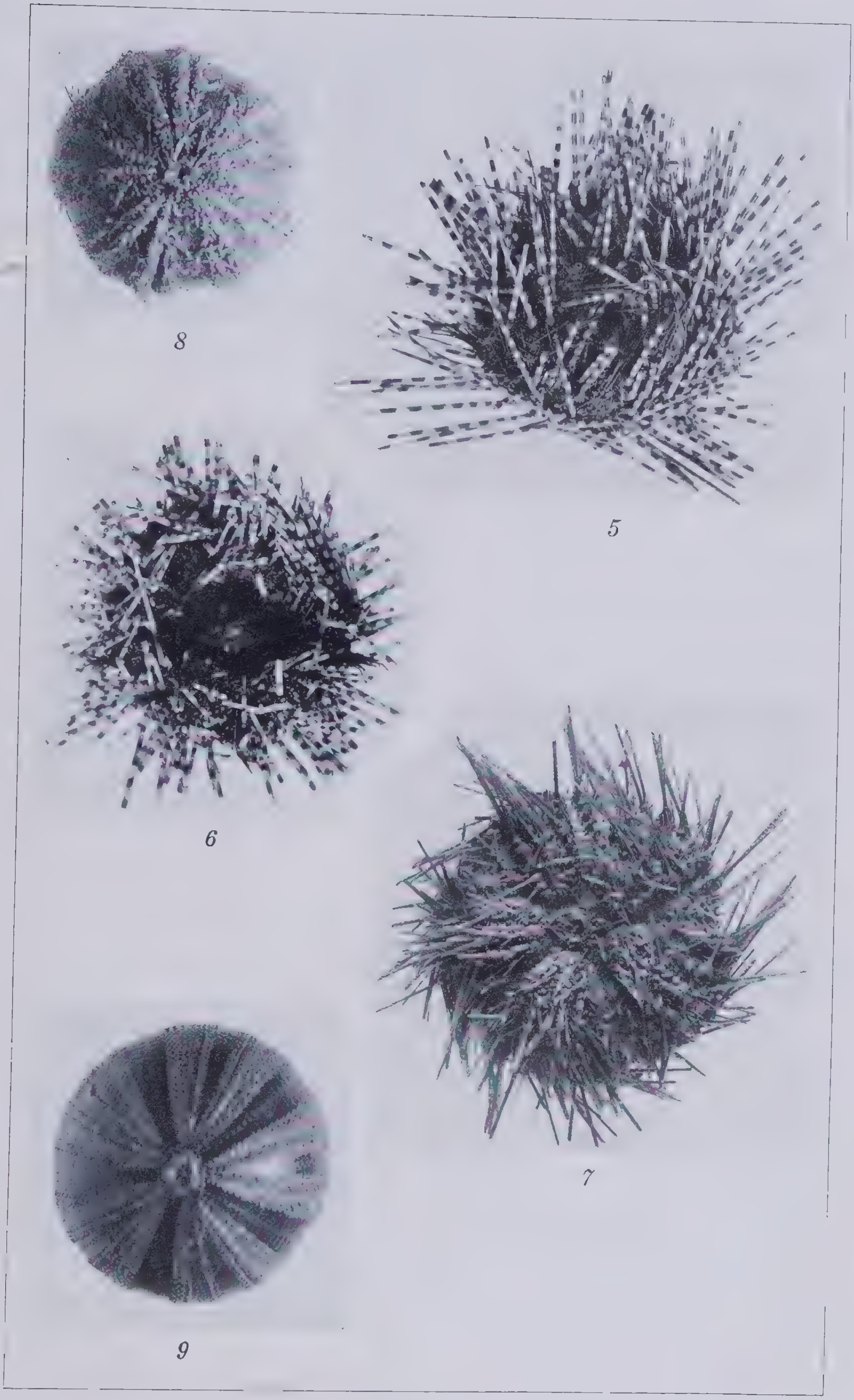

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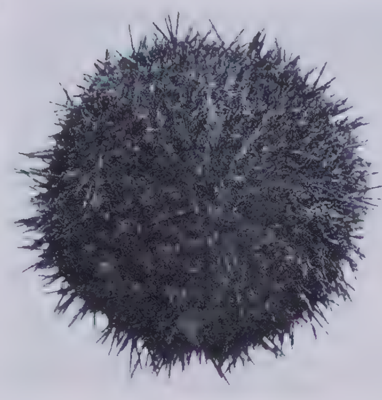

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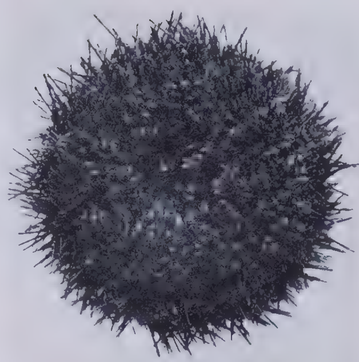

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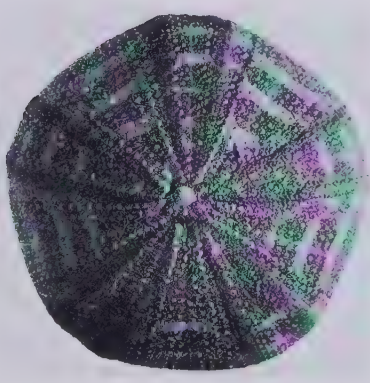

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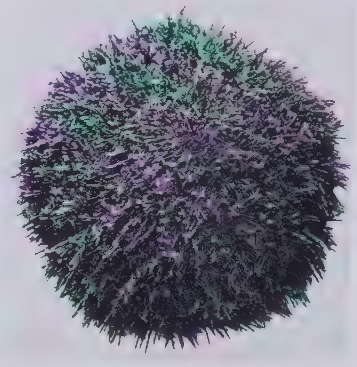

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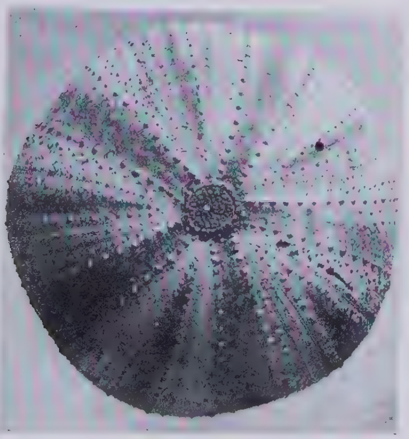

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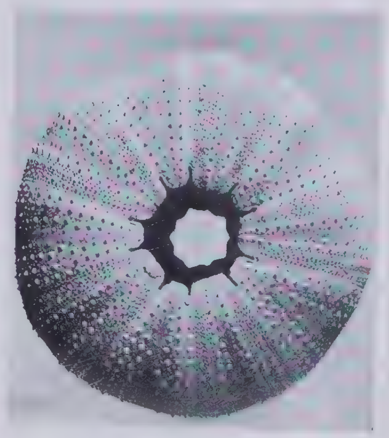

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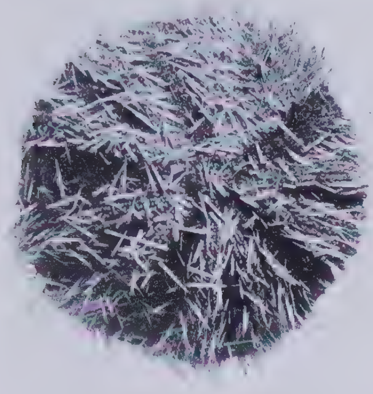

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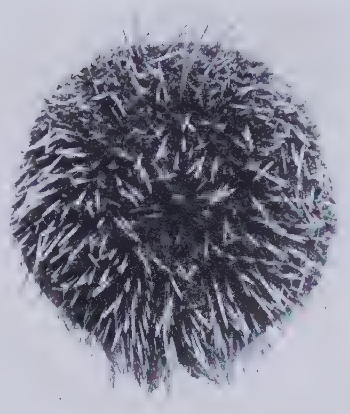

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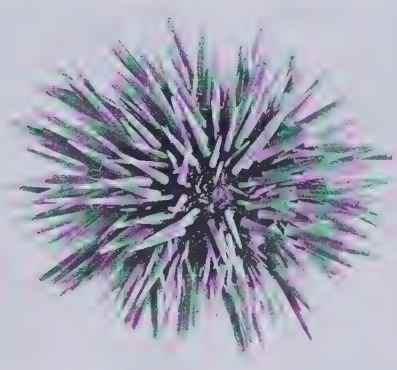

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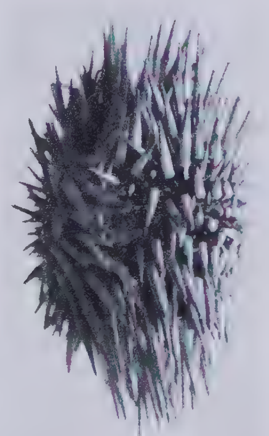

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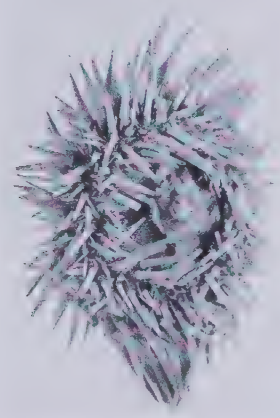

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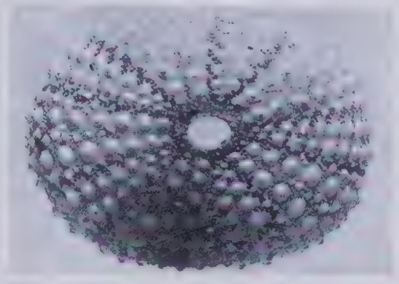

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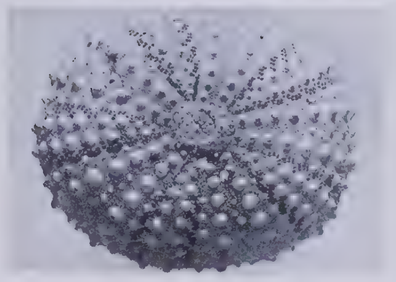

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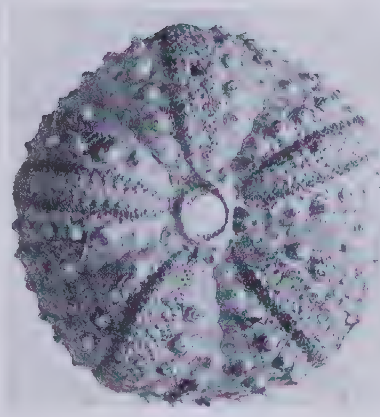

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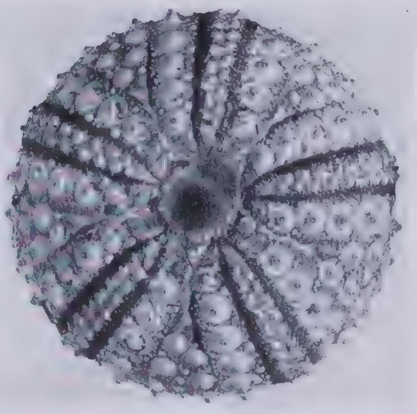

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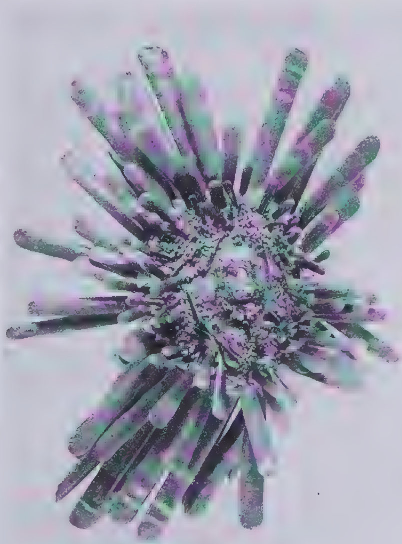

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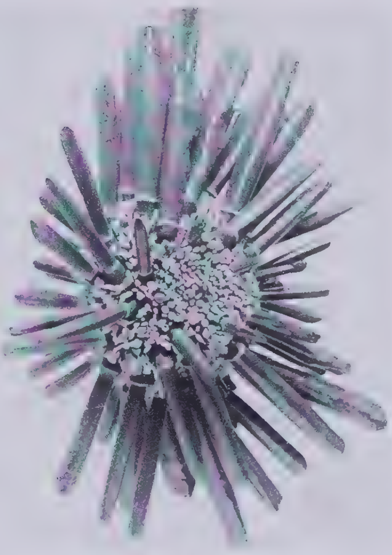

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PLATE 5.

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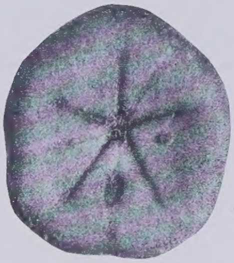

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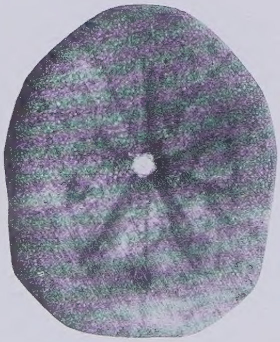

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PLATE 6.

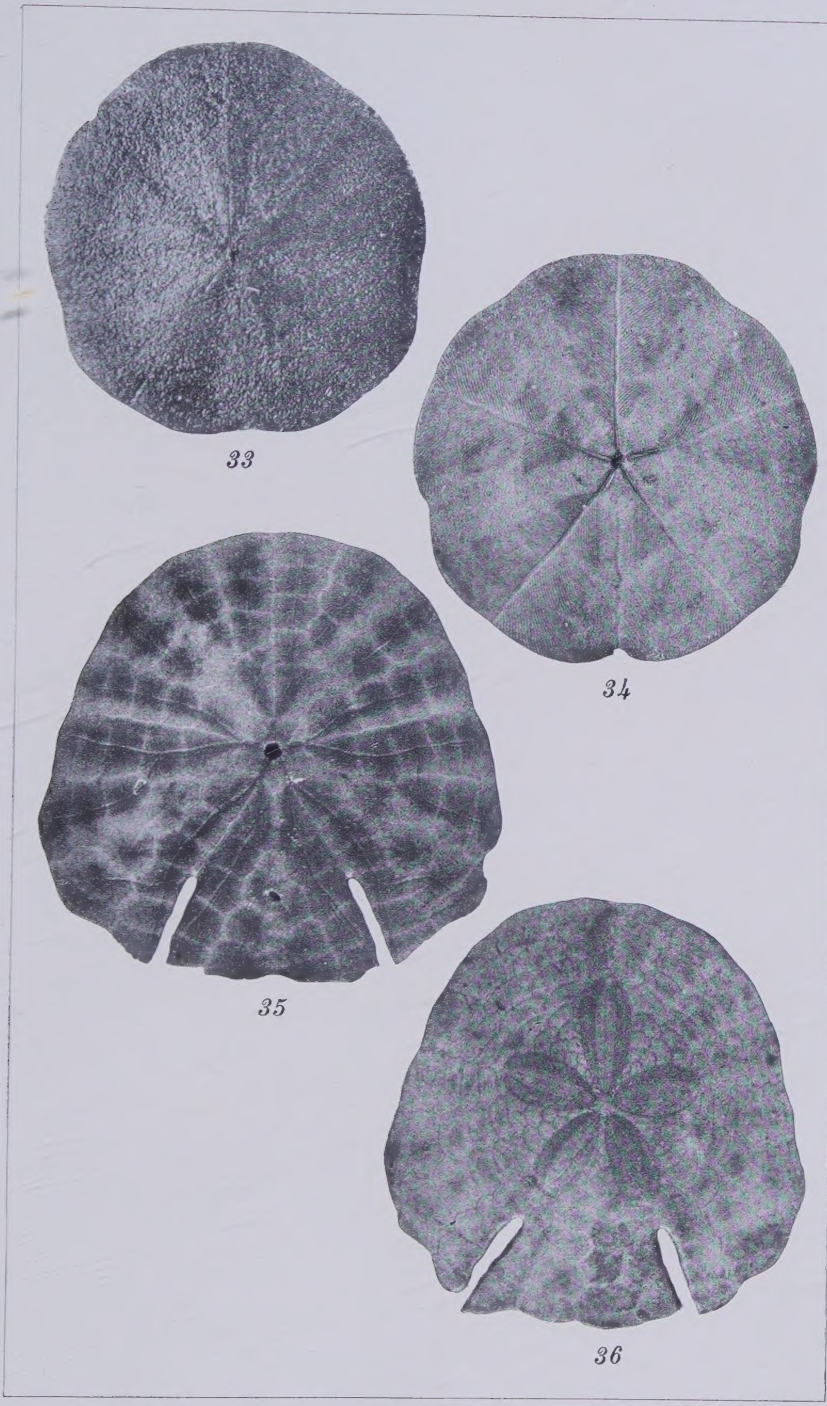

PLATE 7.